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JAN. to DEC., 1917.

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LEON GASTER

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EDITORIAL.

Progress in 1916.

It is customary, at the beginning of a new year, to survey progress during the past twelve months. Owing to the war there is, however, little to record as regards developments in this country. The introduction of the Summer Time (Daylight Saving) Act, the darkening of the streets, the opportunities for economy in lighting—all these are matters of considerable interest, but they were dealt with in the discussion at the last meeting of the Illuminating Engineering Society, reported in our December issue.

We therefore confine ourselves to these few remarks on progress in 1916, in the sincere hope that before the end of another year the present world-conflict will be over, and illuminating engineering will have resumed its normal course.

The Lumen as a Measure of Illuminating Power.

The discussion on this subject at the last meeting of the Illuminating Engineering Society marks an important stage in our progress towards more scientific and definite methods of comparing sources of light. The origination of the Lumen, as a measure of flux of light, and as a basis of comparison of the illuminating power of sources is due to Professor A. Blondel, who first suggested the expression at the International Electrical Congress at Geneva in 1896. It is thus in no sense of "German origin," as one of our contemporaries incautiously suggests. (In any case, the comment is irrelevant. The only points of importance are the convenience and scientific value of the term, irrespective or its origin.) In France, on the other hand, whence this unit originated, the Société Française de Physique passed a resolution about three years ago, advocating rating on this basis ; and in the United States, the Illuminating Engineering Society, which is representative of gas, electricity, and all other methods of lighting, formally adopted this method of rating at the Convention held last September. It was therefore natural that the matter should receive the attention of the Illuminating Engineering Society in this country.

The subject was dealt with in a preliminary discussion before the Society in May, 1914. Even at this time expert opinion was in favour of the proposition that illuminants should be rated primarily in Lumens. The contributions by Professor Morris and Mr. Willcox in this number state very clearly, what has been evident for some years, that the variation in existing methods of rating illuminants has led to endless confusion. The development of sources of light having widely different polar curves of light distribution, and still more the fact that by using appropriate globes or reflectors this distribution can be enormously varied according to our requirements, has made the practice of rating by candlepower in a single direction quite misleading. This method may have had a certain justification in days gone by, when all the lamps available had broadly the same distribution of light. It is no longer justifiable now.

These variations in distribution of light have only become generally apparent within the last few years, owing to the more general use of polar curves. They are not confined to any form of illumination ; gas and electric lamps alike vary greatly in their distribution of light ; and rightly so, because we could not otherwise obtain so easily the effects we desire in practice. It is, however, essential that these variations should be understood, recorded, and utilised, and we have therefore never failed to insist on the desirability of makers furnishing polar curves with their lamps. Now such curves are fairly familiar, though still not as generally employed as we could wish. The comparative novelty of the idea is shown by the fact that when Mr. J. G. Clark read a paper, describing their use before the London and Southern Junior Gas Association in 1910, several journals, in commenting on the proceedings, hinted that he was soaring above the minds of his audience, although they implied that an occasional "soar" was a necessary element in the propagation of new ideas. The arguments now brought forward in defence of the polar curve constitute a gratifying sign of progress, but we may say at once that none of the advocates of the Lumen have the least intention of advocating its disuse. The study of distribution of light is absolutely essential to illuminating engineering. Whatever changes in rating may be made, polar curves will still be necessary, and will, we hope, be even more fully utilised in the future.

Nor is there the least likelihood that the useful conception of candlepower will be lost, nor that this term will be banished from our vocabulary.

It is obvious, however, that in referring to the lamps we use every day, in stating in conversation the illuminating value of a source, and in compiling statistics or tables illustrating progress in illuminants, it is impossible to reproduce, either graphically or orally, the polar curve of a lamp every time we have occasion to refer to its illuminating value. For such purposes we must have a number representing, as completely as possible, the potential illuminating power of a source of light. It is now generally accepted that such a number should not represent only the candlepower in a particular direction. The correct procedure is to specify the total light in all directions, recognising that this light can be distributed as we desire by shaping the reflectors, &c., and providing the polar curves relating thereto when required. The general adoption of such a method of rating would mean that in future we should obtain a proper record of improvements in the luminous efficiency of sources, and that whenever any advance is announced we should be able to judge at once whether it was really an improvement in efficiency, and not merely a concentration of light in some particular direction.

The question next arises how this total illuminating power of a lamp is best defined. We have a choice between rating lamps "in mean spherical candlepower" or in the total flux of light in Lumens. The latter quantity is obtained numerically by multiplying the mean spherical candlepower by 12·57 (4π), but is essentially a different unit being the product of the candlepower multiplied by the solid angle over which it operates. We agree that rating in mean spherical candlepower would represent a great advance over present methods, and in the past we have frequently urged the more general use of such values, or at least the provision by manufacturers of a factor enabling the candlepower in the horizontal or maximum direction to be converted into spherical candles. At the same time we have always been impressed by the scientific arguments on behalf of the Lumen, and regarded the adoption of mean spherical candlepower merely as a transition stage in the direction of the Lumen. Now that circumstances seem favourable to the adoption of this unit, there is good ground for the suggestion that we should take the final step.

The scientific arguments in favour of the Lumen may be briefly summarised as follows :—

(1) Mean spherical candlepower is an imaginary quantity. Few, if any, existing sources approach a "point-source" in dimensions, or radiate uniformly in space. But the flux of light in lumens is a real quantity, independent of the area of the source or its distribution.

(2) In every calculation in which mean spherical candlepower is obtained, we must first obtain the total flux of light ; the latter, therefore, and not the former, is the fundamental quantity expressing the total illuminating power of a source.

(3) Determination of mean spherical candlepower from polar curves is tedious, and, in the case of sources whose distribution about a vertical axis is not symmetrical (such as lamps with parabolic mirrors, many flames, &c.), very difficult. It is therefore advisable to develop alternative methods of direct measurement, such as the Ulbricht sphere, and these methods essentially measure flux.

(4) Mean spherical candlepower is of no practical utility in calculations. The flux in Lumens is useful, and a knowledge of the flux of light of any beam leads at once to a rapid estimate of the average illumination on any surface on which it impinges. In studying the path of beams of light, and in expressing brightness, the use of Lumens leads to great simplification and avoids the anomaly of two distinct methods as specifying the latter quantity (candlepower per square inch and equivalent foot-candles.

(5) The word Lumen is understood in all the chief countries of Europe and in America. The words used to indicate mean spherical candlepower differ according to the language.

These considerations cover the chief scientific grounds for preferring the Lumen. In addition, the change happens to be convenient from the commercial standpoint. Not only to makers of electric lamps, but also to makers of incandescent gas lamps, the change would be, in the long run, a benefit in enabling us to cut adrift from the uncertainties involved in uni-directional measurement of candlepower. So far from favouring, imposture, rating in Lumens would at once reveal the true values of lamps about which there is at present much dispute. For example, we should appreciate at their true value the relative illuminating powers of half-watt and ordinary metallic filament lamps, and we should also be enabled to see the position of the smaller gas-filled units, for which the candlepower is not stated, and which, while probably marking an advance over the vacuum lamp, are by no means entitled to be described as "half-watts."

As a further precaution against possible misrepresentation, we are strongly of opinion that makers of all types of lamps should make a practice of having standard varieties tested at the National Physical Laboratory and publish the results. These would give, within reasonable limits due to manufacturing discrepancies, an authoritative ruling as to their performance. In this way the change would operate not only as an aid to makers of lamps and lighting appliances, but for the benefit of the general public.

Again, the mere fact that the earliest legislation regarding the measurement of light relates to candlepower is not in itself a good reason for adhering indefinitely to this method. During recent years gas engineers have ceased to attach the importance to measurements of the illuminating power of gas that they once had, and already the value of gas is rated on a calorific basis. There is therefore no valid reason for persisting in rating incandescent gas lamps in candlepower, if Lumen values were found more convenient. We recall that about six years ago Mr. C. O. Bond, in a paper before the American Gas Institute,* entitled "A Survey of Gas Photometry," was already giving results in Lumens per British Thermal Unit per hour.

Lastly, we should like to point out the misconception that the units employed for scientific and technical work must be selected only with a view to continuance of past practice and the convenience of the "man in the street." The selection and definition of such units must be determined by the expert, not by the man who knows nothing about the subject, and naturally cannot be expected to appreciate the importance of a new departure. Having made our decision on scientific grounds, we should naturally do everything possible to make the departure intelligible to the general public, and to introduce it into practice by degrees. The suggestion that the Illuminating Engineering Society should prepare a pamphlet describing the use of the Lumen in simple language, is a good one, and patient educational work will be needed. We may add that the meaning of the term is quite understood by experts, and that the various definitions mentioned in the discussion are mutually consistent. It is only for the sake of scientific precision that further definition is needed, and we hope that a little patience will soon make the term familiar to those interested in its use.

LEON GASTER.

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* *Proc. Am. Gas. Institute*, 1911, Part I., p. 537.

TRANSACTIONS

OF

The Illuminating Engineering Society.

(Founded in London, 1909.)

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

THE LUMEN AS A MEASURE OF ILLUMINATING POWER.

(Proceedings at a meeting of the Society held at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, W., at 5 p.m. on Tuesday, January 16th, 1917.

A meeting of the Society took place as stated above on Tuesday, January 16th, 1917, at 5 o'clock, Mr. A. P. TROTTER in the Chair.

The Minutes of the last meeting having been taken as read, the Hon. Secretary read out the names of applicants for membership announced at the last meeting,* and these gentlemen were formally declared members of the Society.

In addition, the names of the following new applicants for membership were announced :—

The Hon. Secretary remarked that the nomination as members of a number of the chief inspectors of the Gas Light & Coke Co., and the South Metropolitan Gas Co., was a gratifying recognition of the importance of the work of the Society. It was to be hoped that other gas companies throughout the Kingdom would follow their lead and nominate a number of their staff as members of the Society.

The Hon. Secretary added that, in accordance with the usual arrangement with the Institutions of Gas and Electrical

Vice-Presidents :—

Broadberry, A. E.	Chief Engineer, Tottenham and District Light, Heat and Power Co., High Street, TOTTENHAM.
Jones, H. E.	Chairman of the National Gas Council, Palace Chambers, WESTMINSTER, S.W.
Watson, D. Milne	Managing Director of the Gas Light and Coke Co., Horseferry Road, WESTMINSTER, S.W.

Ordinary Members :—

Barker, J. W.	Inspector-in-Charge, The Gas Light and Coke Co., 40-42, Barking Road, EAST HAM (1).
Creasey, H. H.	Assistant to the Controller of Gas Sales, The Gas Light and Coke Co., 27, Orpington Road, Winchmore Hill, LONDON, N. (1).

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* *Illum. Eng.*, Dec. 1916, p. 365.

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Engineers, Mr. A. E. Broadberry, the President of the Institution of Gas Engineers for the current year, had been created a Vice-President and member of Council of the Society.

The Society had also been honoured by acceptance to act as Vice-Presidents on the part of Mr. HARRY E. JONES, the Chairman of the newly-formed National Gas Council, and Mr. D. MILNE WATSON, the Managing Director of the Gas Light and Coke Co., who would take the place left vacant by the death of the late Sir Corbet Woodall.

The Chairman then called upon Professor J. T. MORRIS to open the discussion on **The Lumen as a Measure of Illuminating Power,** and Mr. F. W. WILLCOX subsequently presented a contribution to the discussion in which this subject was fully treated by the aid of appropriate curves and diagrams (see pp. 10-25).

In the subsequent discussion Mr. S. H. CALLOW, Mr. A. BLOK, Mr. J. G. CLARK, Mr. L. RABONIVITCH, Mr. G. CAMPBELL, Mr. E. STROUD, Mr. R. A. IVES, Mr. A. WISE, Mr. C. H. PITMAN, Mr. J. S. DOW, and Mr. L. GASTER took part.

The CHAIRMAN, in winding up the discussion, alluded to the importance of the proposal that lamps should be rated in terms of the total flux of light and emphasised the need for a thoroughly scientific and precise definition of the Lumen. Professor MORRIS and Mr. WILLCOX briefly replied to some of the points raised.

The Chairman announced that the next meeting would take place on Tuesday, February 20th, when a paper would be read by Dr. JAMES KERR (*Public Health Dept., London County Council*), on **The Effect on the Eye of varying degrees of Brightness and Contrast.**

THE LUMEN AS A MEASURE OF ILLUMINATING POWER.

By J. T. MORRIS.

(Professor of Electrical Engineering at East London College).

(Introduction to the discussion of the Illuminating Engineering Society held at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, W., at 5 p.m., on Tuesday, January 16th, 1917.)

AT a discussion of the Society held in March, 1915, the rating of illuminants in terms of consumption of gas or electricity and illuminatng value was discussed.

It was then pointed out that the distribution of light from modern illuminants differs so greatly, and can be modified so readily by the use of appropriate globes and reflectors, that no method of evaluation based on the light emitted in any one direction is satisfactory. It is now generally agreed that illuminants should be rated in terms of the total amount of light yielded in all directions, although information regarding the distribution of light (polar curves, &c.) is necessary for certain purposes.

What exactly is meant by the statement that the candlepower of an incandescent electric lamp is, say 50? The statement implies that if we divest the lamp of its fittings, and then measure the candlepower in a horizontal direction, the illumination derived will be 50 times that obtained from a standard candle placed at the same distance. But such a value bears no relation to the performance of the lamp in practice. Nowadays it is essential to use most lamps with an appropriate globe or reflector, and one could hardly mention a lamp without thinking of it as a complete unit with its proper shade or reflector around it. Many such complete units, for example those specially designed for street lighting, give practically no candlepower in the horizontal direction.

It is clearly necessary to take into account the candlepower from the lamp in other directions as well as that in the horizontal direction; for (assuming that the distribution of light is symmetrical about a vertical axis) the candlepower at all angles can be represented by the well-known polar curve of light distribution. Such curves are essential to the expert in judging the suitability of lighting units for various purposes, but the information contained in such curves could not readily be summarised in a single figure for rating purposes.

Further, there are other sources, such as the half watt lamp, the candlepower of which in a horizontal direction is difficult to determine, a small change in angle making a considerable difference in candlepower. Without a clear agreement as to the conditions under which candlepower is to be measured, it is very difficult, when rating their efficiency, to compare such lamps with one another or with ordinary tungsten lamps.

Therefore the only proper basis of comparison of such lamps must be in terms of the total amount of light emitted in *all* directions.

The desirability of rating illuminants in terms of mean spherical candlepower has been often urged. The adoption of this would lead to the presentation of lower numerical values than those previously put forward, which from a commercial standpoint is objectionable. In addition, the mean spherical candlepower is only an imaginary quantity and somewhat difficult of conception, since in practice we do not meet with any source which gives exactly the same candlepower in all directions. The nearest approximation to such a source is the " Pointolite " lamp invented by Lieut. Mullard of the Edison and Swan Electric Co., which was shown before the Society in the Autumn of 1915. In the case of the great majority of lamps, and especially lighting units comprising a lamp within a globe or reflector, the light emitted in different directions varies enormously. In order to conceive of the mean spherical candlepower it is therefore necessary to imagine that the source gives out the same total amount of light but redistributed so as to be equal in all directions, as is practically the case in the white hot ball of tungsten in the Pointolite Lamp, as already stated.

It is clear that if mean spherical candlepower were to be generally adopted for the rating of lamps the candlepowers assigned to them would be, in almost all cases, considerably lower than that credited to them by present methods. In practice this might not be convenient. If a consumer found that he was being offered a lamp of the same consumption as before but with say 100 instead of 120 c.p. he would be apt to jump to the conclusion that it was a poorer article and it would then be necessary to try to explain to him the difference between mean spherical candlepower and mean horizontal. This might seem a small point but it is one that the Society would have to consider were they to recommend a change in rating.

Recently, however, the suggestion has been brought forward that lamps should be rated in terms of the total flux of light, the unit of which is the Lumen. This term was originally proposed by Professor Blondel, of Paris, at the International Electrical Congress at Geneva in 1896. While the exact definition to be given to this term may be a subject for the consideration of the Society, it is perhaps best explained as the flux of light received by a surface one square foot in area, and having an illumination over its area of one foot-candle. In view of the fact that during recent years the foot-candle has become such a familiar unit in this country, this is perhaps the easiest method of approaching the conception of the Lumen. The above definition is also equivalent to stating that the Lumen is the flux of light emitted by a source of unit candlepower in unit solid angle. The solid angle subtended at its centre by a spherical surface is 4π, and the flux in Lumens from any source is therefore obtained by multiplying the mean spherical candlepower by this figure.

On the Lumen rating, therefore, a 40 c.p. lamp would be sold as a 350 or 400 Lumen lamp in future. This is a much larger figure, and some people consider that in illuminating engineering calculations this is an advantage. In addition, by breaking new ground and adopting a new system of rating, the difficulty of the apparent reduction in candlepower of lamps arising through rating in mean spherical candlepower would be avoided.

In the Report of the Committee of the American Illuminating Engineering Society on Nomenclature and Standards presented at the Convention last September, it is definitely specified that illuminants should be rated in terms of Lumens in the future and it is understood that this decision will be adopted and put into practice by the lamp makers in the United States. It is believed that in Germany the whole question of the rating of lamps is also being discussed, but the final consideration of the matter by the Illuminating Engineering Society Committee in that country appears to have been suspended owing to the war.

In this country, also, it seems that the makers of electric lamps contemplate adopting the Lumen, though it may be necessary also to state candle-power values and to show their relation to Lumen values during the transition period. Obviously the change must be accompanied by efforts to make the new method of rating widely known and understood. Again, once the lamp makers have adopted the necessary photometric apparatus the ease of measurement and certainty of the result will recommend methods based on the measurement of total flux of light.

It will be observed that, apart from the loss of light involved by the use of a globe or reflector with a lamp, the output of the combined unit in Lumens should not be affected by any measures that are taken to alter the distribution of light. If the Lumens in each zone from such a unit are tabulated the summation of these values gives at once the total flux of light, and by comparing this with the output in Lumens of the lamp used, the efficiency of the globe or reflector can be readily ascertained. This is an interesting point because the method would reveal many cases in practice where the flux of light available from the lamps used has not been efficiently utilised and would suggest opportunities for improvements in the existing methods of distributing light.

It is also convenient to work with Lumens in the usual formulae for determining the average illumination in a room resulting from a given arrangement of lamps, and particularly when the approximate average illumination over an area needs to be quickly determined. It also facilitates calculation of the illumination derived from extensive illuminated surfaces, such as occur in the case of indirect lighting. Again we find ourselves almost compelled to utilise the conception of flux of light when dealing with concentrated beams such as occur in the searchlight and the optical lantern. In dealing with the illuminating value of beams differing in dispersion, rating of the unit in terms of Lumens is certainly worthy of careful consideration.

The time is therefore ripe for the discussion of this subject by the Illuminating Engineering Society, and it is hoped that this meeting will be useful in eliciting the views of those concerned both with the rating of lamps and their use in practice.

JUVENILE EMPLOYMENT.

Attention has recently been drawn to the admirable researches carried out under the supervision of the Committee on the Health of Munition Workers on the relations between hours of work and fatigue.

In a recently issued Bulletin (No. 13) the conditions of juvenile labour in factories is discussed. It is pointed out that many factors that have a depressing effect on workers generally, especially overtime, have a specially bad effect on children. Expressions of opinion of factory inspectors are quoted to the effect that in many workshops children are being seriously overworked. Continued long hours give rise to a condition of general lassitude, dullness, and weariness that must have a prejudicial effect alike on the work and the health of the children. It is strongly advised that in no case should boys under 16 work for more than 60 hours a week. Eight hours of sleep are the minimum.

Equally important is the general care of children to whom the general supervision and guidance of older people is often essential. Facilities for recreation can do much to prevent staleness and fatigue. An interesting account is given of the work of Boy Visitors, who appear to be doing a most valuable work in supervising the well-being of juvenile workers and removing conditions that may lead to permanent deterioration in physique.

THE LUMEN AS A MEASURE OF ILLUMINATING POWER.

By F. W. Willcox.

(Contribution to the Discussion of the Illuminating Engineering Society held at the House of the Royal Society of Arts, 18, John Street, Adelphi, W., at 5 p.m. on Tuesday, January 16th, 1917.

This is the third time within the writer's knowledge that the subject of the Lumen has been discussed before this Society. The first occasion was the very able paper by Mr. A. P. Trotter on "Nomenclature and Definition of Photometric Magnitudes and Units" before the Illuminating Engineering Society's meeting, May 31st, 1914.

Again, at the March 16th, 1915, meeting of this Society, the writer presented a paper on the "Practical Rating of Incandescent Lamps," the latter part of which was devoted to a discusion of the Lumen as the desirable unit for expressing luminous values.

Mr. Trotter in his paper presented a most able argument in favour of the retention of candlepower as against the adoption of a new unit, but the writer thinks it is clearly shown in the discussion contributed by Mr. C. C. Paterson and Prof. Blondel, that the trend of scientific work and definitions was at variance with the ideas and system advanced by Mr. Trotter, and that evolution of practical experience unavoidably leads to a flux conception in lighting problems.

Since that time, developments in illuminating work, particularly in electric lamps, with the increasing varieties of filament shapes, have emphasized more than ever the need of some more definite unit than candlepower for expressing luminous values. As Prof. Blondel stated, photometric units should be—

1st, Scientific—that is to say, in direct and intimate relation with other branches of physics and carried to the same degree of scientific precision.

2nd, International—that is to say, containing terms capable of being adopted for all countries.

He pointed out that the word "*candlepower*" is not possible to adopt internationally, because while such a term is rendered venerable by its years of usage in England, it is completely unknown in other than Anglo-Saxon countries.

Prof. Blondel then states "the photometric system should be framed to meet the requirements of science, and not to comply with the old-fashioned practices dating from the early days of public lighting, nor to meet the views of those who, as Mr. Trotter says, 'know little or nothing about angles and flux.' On the contrary, the system should be *in advance* of its time. It should provide engineers with scientific ideas of illumination and conceptions in harmony with the progress of other branches of physics. It is for these reasons that it is necessary to define luminous flux (a special form of energy) before proceeding to define the source of light. The conception of a flux is so convenient in practical lighting problems, both as regards interior and public lighting, that people have come to make constant use of it, and in fact can hardly avoid doing so. And how is it possible to define illumination in a scientific manner without recourse to this quantity."

Supplementing these points, Mr. C. C. Paterson, of the National Physical Laboratory, said that the conceptions of light as a flux is a very natural and common one, and the expressions frequently used, such as a lamp "shedding" light, and "floods of light" indicate that the common every-day conception of light is that of a flux and not that of illumination.

Mr. Paterson further stated: "I really do not think it is possible to get rid of flux as the primary idea in light, for the reason that if we look at all other branches of physics where radiation or its equivalent is concerned, there is none in which the idea of flux is not the fundamental one." He instances the cases of sound, heat and magnetism as subject to this condition. He then says: "This being the case, I think with light we ought to keep our definitions on all fours with our definitions and conceptions in other branches of science. Radiated energy is always thought of, not as the source which is radiating it, but as the 'something' which is passing through the ether towards us. Therefore I venture to suggest that if we adopt Mr. Trotter's suggestion we shall be introducing an entirely new system into scientific definitions, and we ought to have some very good reason indeed before deciding to do so."

These remarks deal with the important theoretical points in the discussion of May, 1914. In the paper the writer presented at the April, 1915, meeting, he endeavoured to give some practical reasons in support of the Lumen as bearing on the question of Electric Incandescent Lamps.

It is proposed in this paper to summarise the situation to date, which necessarily, of course, includes a repetition of some of the points already presented, in order to present a full case for Lumen and show its practical value and application in lighting and illumination problems. In order to do this, it would be well for us to start with the deficiencies of candlepower as a unit, which deficiencies are becoming increasingly emphasized from year to year, and have rendered it necessary seriously to consider a more suitable unit for definitely expressing luminous values. Candlepower will be retained as the unit of luminous intensity, but just as in the case of a pump, the pressure which the pump exerts gives no proper indication of its capacity, so in the case of illuminants the candlepower gives no complete indication of the actual quantity of light given by the illuminant.

Defects of Candlepower Rating.

The fundamental requirement is a definite unit which will always clearly and invariably express one thing. This condition the Lumen complies with and the candlepower unit does not. We well know, for example, the numerous varieties of candlepower, such as the mean horizontal, mean spherical, the upper mean hemispherical, and the lower mean hemispherical, the maximum candlepower values in different directions, and the "apparent" candlepower values obtained when we put a lamp in a reflector and re-distribute the light. Such complications do not arise with the Lumen. When employed either as a measure of luminous value or to express the efficiency of the illuminant, its terms are precise. For example, when we express the efficiency of an electric lamp in the usual term "watts per candle," a query arises as to what variety of candle is meant—whether the mean spherical or the mean horizontal or the tip end value, etc.—whereas "watts per lumen" or "lumens per watt" is wholly definite.

Again, the unit of luminous values should not permit of manipulation by the alteraton of its apparent value through change of the shape of the luminous body (the lamp filament) or through the use of any external accessories, such as reflectors, etc. Experience has shown that alteration of values by this means has been the chief defect of candlepower as a unit. Numerous examples may be given, as it is common knowledge how the filament of an electric lamp can be reshaped and concentrated so as to give its maximum value in any given direction, and by simply frosting or silvering the upper part of the glass bulb, a lamp may be made to give apparently very much increased candlepower value for the same energy from the same length and section of filament.

Again, the variations in candlepower values obtainable in different directions with different kinds and shapes of reflectors is well known to all. The same amount of light flux (Lumens) is made to give—now 50, now 100, now 500 or more candlepower value.

It is not necessary to labour these points, and I will simply refer my audience to the illustrations accompanying the paper.

Fig. 1 shows the various forms of electric lamp filaments and indicates the exceeding difficulty of trying to assign candlepower values to many of these shapes. This is apparent when we consider the light distributions as shown in Figs. 2, 3, 4 and 5. When we consider such cases, the use of the Lumen strongly recommends itself, for the simple reason that the Lumen cannot be manipulated. The luminous output of a lamp as expressed in Lumens remains the same, whatever the shape of the filament, and no matter what variations of external arrangements or what accessories (reflectors, etc.) are employed with the lamp (always of course allowing for any absorption losses there may be in the accessories).

A good example of the value of a definite unit such as the Lumen for the purpose of accurately recording steps in progress in lighting is afforded by the curves shown in Fig. 6.

In this figure the advances in the efficiency of conversion of energy into light in electric incandescent lamps is traced, from the earliest developments up to the present date. Here we see how a unidirectional method of expressing candlepower fails to give a proper measure of the illuminating power of the half watt lamp.

Similar results would doubtless be obtained if the changes in efficiency of other illuminants were plotted in a diagram of this kind. For, in all such cases advances in efficiency are commonly accompanied by changes in the distribution of light. The curve giving the values in Lumens per watt, however, gives a true record of the advance secured.

A further serious defect of candlepower is that the value materially alters (as in the case of light distribution curves), according to the direction in

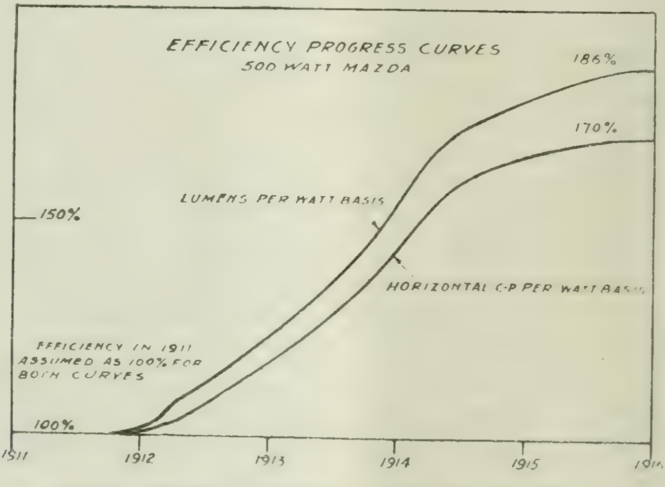

FIG. 6. Advance in electric incandescent lamp efficiency.

The above curves show the advance in the efficiency of electric lamps over a number of years. The lower curve expresses the efficiency in "*Horizontal Candlepower per Watt*"; the upper curve the efficiency in "*Lumens per Watt.*" It will be observed that the two curves are parallel up to a point, until the Gas-filled ("Half Watt") Type Lamp enters in, and from here onwards the "Lumens per Watt" curve rises more rapidly than the other curve. This is explained by the fact that the new Gas-filled Type Lamps have a different spherical reduction factor from that of the previous Vacuum Type Lamps. The improvement in efficiency given by the Gas Filled Type Lamps is thus not fully expressed by the curve expressing "Horizontal Candlepower per Watt." With "Lumens per Watt," as expressed by the upper curve, we have the full case accurately represented for the new type and for all types of lamps, thus giving a true and full record of lamp development.

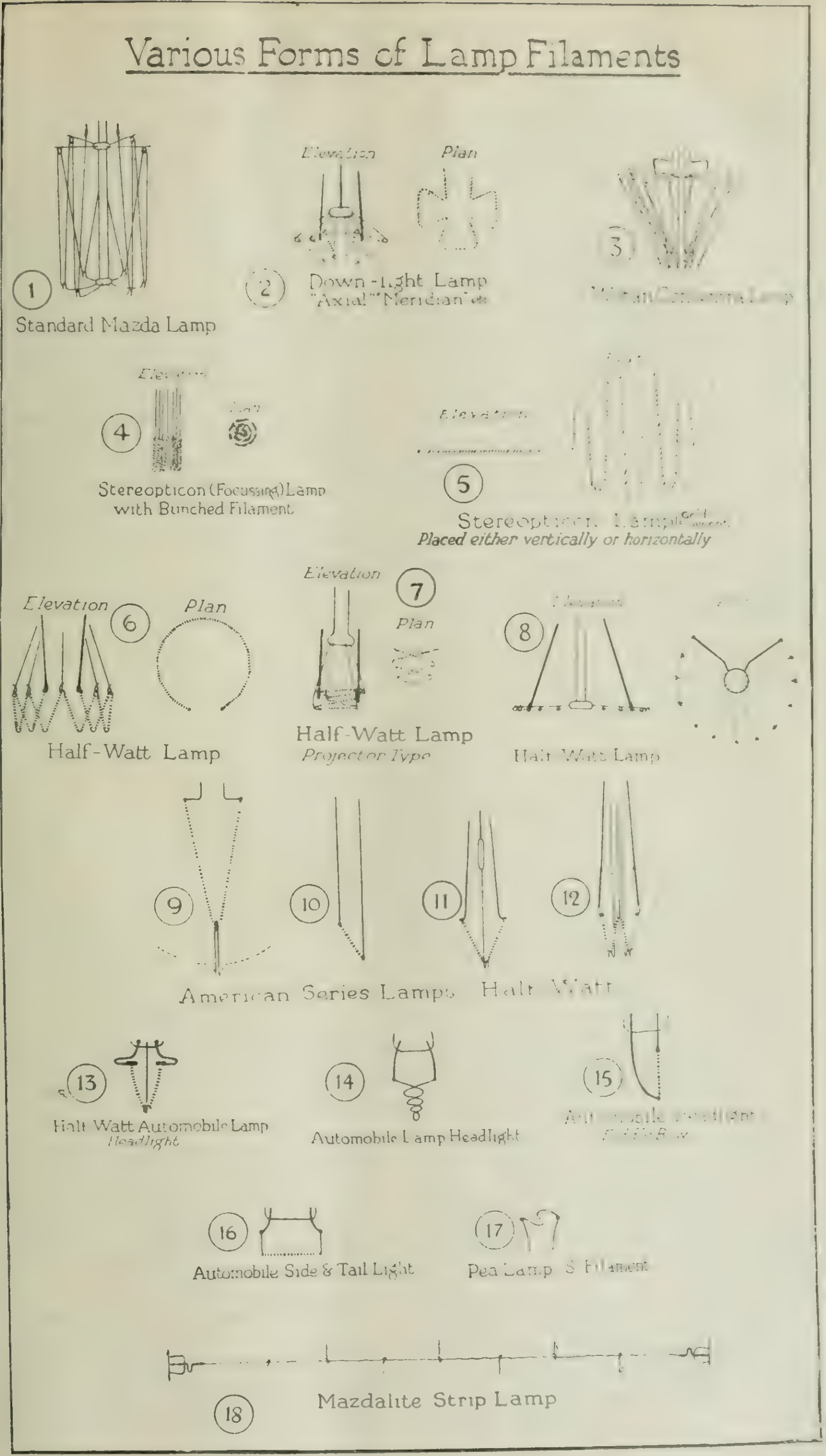

FIG. 1.—Various Forms of Electric Lamp Filaments, showing the impracticability of rating in candlepower values.

which it is measured. Practically a unit of candlepower should have the same value whether measured horizontally, vertically, or at any angle. Actually we know it does not, as is shown by a consideration of the spherical surface surrounding a lamp. The average person quite fails to understand why merely taking the numerical average of the candlepowers represented at each point on the polar curve of light distribution fails to give the value in mean spherical candlepower. This is a somewhat mysterious and complicated problem to a layman. Even those who understand the subject fully are in difficulty to properly judge of the merits of different candlepower curves without employing a planimeter or Rousseau diagram. Such a condition tends to misleading results and frequent misrepresentations in support of unfulfilled claims. Whenever anyone objects to the Lumen as a scientific unit that is difficult to understand, I am always reminded of the exceeding complexity involved in the candlepower distribution curves and the Rousseau diagram. Surely a unit such as the Lumen, which definitely means one thing, will be far easier to explain to and be understood by those who are dealing with illumination, than candlepower with its varieties of mean horizontal and mean spherical, etc., and such complications as Rousseau diagrams, etc.

Diagrams in Figs. 7, 8, and 9 clearly illustrate the difficulties just stated. It is hopeless to ever expect people to understand the apparent inconsistency of these different curves containing very unequal areas and yet representing the same volume of light. These difficulties are continually emphasized with the elaboration of reflectors and forms of glassware, as employed in modern illumination work.

The case is no longer that of the early days—the simple light value given by a lamp in a given direction. The modern case must provide for expressing luminous values given by lamps in combination with reflectors or glassware, distributed directly or indirectly via the ceiling, or part directly and part indirectly as in semi-indirect lighting. Diagrams in Figs. 10 and 11 illustrate this point and show two characteristic cases of the light distribution from modern lighting equipment. The idea of flux of light suits these complex conditions admirably, and the Lumen correctly expresses luminous values for all cases and conditions

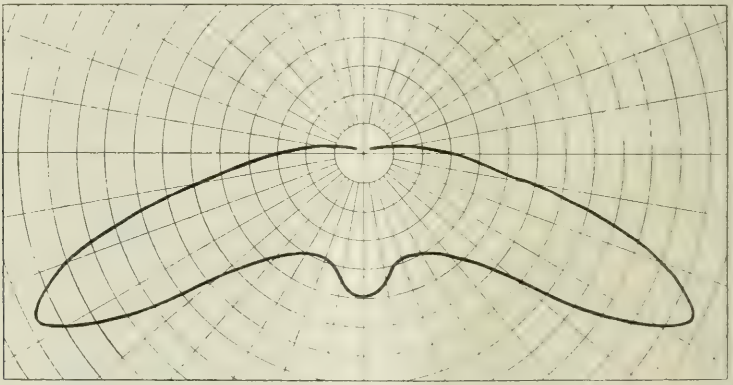

FIG. 11.—Light distribution from "Strela" Fitting, with Holophane Refractor, showing special character of light distribution desirable for street lighting —a contrast with the distribution curve shown in Fig. 10, and illustrating the extreme variations to be dealt with in lighting problems.

The general idea of the Lumen and candlepower can be quite clearly illustrated by an analogy.

An Analogy for the Lumen.

Let us take the case of a lake, and assume that it had been the practice to rate the capacity of lakes by the depth along a given line, drawn through the centre of a lake at its widest point. This average depth would correspond with the mean horizontal candlepower of a lamp.

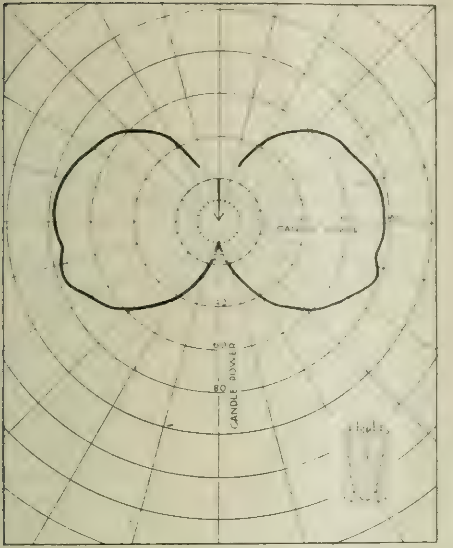

FIG. 2.—Light distribution from 100 watt Standard Metal Filament Lamps. (Filament No. 1 in Fig. 1.)

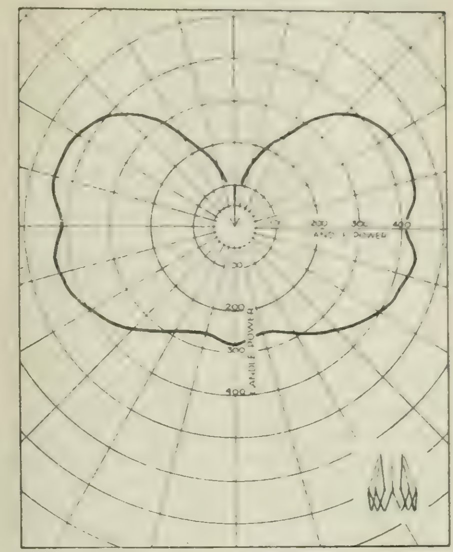

FIG. 4.—Light distribution from 300 watt Half-watt Type Lamp. (Filament No. 6 in Fig. 1.)

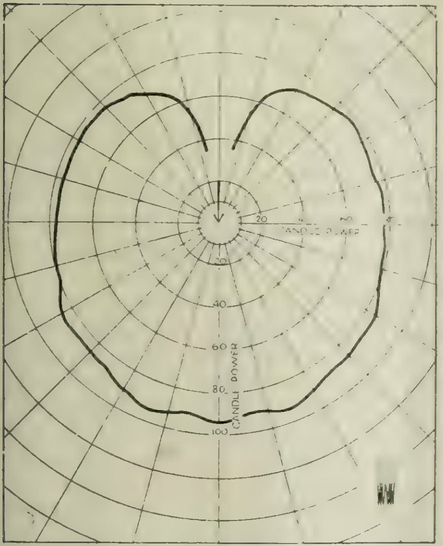

FIG. 3.—Light distribution from 100 watt Focusing Lamps. (Filament No. 4 in Fig. 1.)

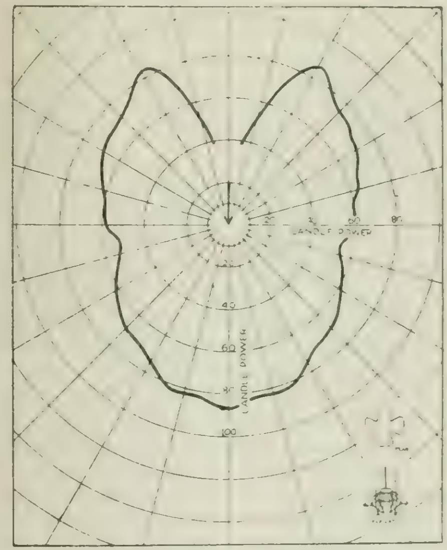

FIG. 5.—Light distribution from 100 watt Spiralised Filament Lamps. (Filament No. 2. in Fig. 1.)

This form of measnre would do fairly well so long as lakes have a general common contour at the bottom and similar surface areas. It would be manifestly a very incorrect measure for lakes of different shapes and sizes, *e.g.*, long lakes like a river, as compared with round lakes or lakes of wholly irregular shapes. It would also be evident that this method of measurement could be abused by any owner of a lake digging out a section of it along the centre line to greater depth so as to claim that his lake, by reason of its greater average depth, had a greater capacity than some other lake. If the average depth were taken covering all points in the lake, we would have a more definite measure of the lake's capacity. This would correspond to the mean spherical candlepower basis for a lamp, Even this measure, however, would not be much less satisfactory as a basis for clearly expressing the volume of water in lakes of widely varying shapes. A more definite measure specifying the volume of water, such as a statement of the number of gallons, would be desirable. This measure would be analogous to the Lumen.

Another analogy can be drawn from casks or barrels. Supposing it had been the practice to rate the capacity of barrels by the diameter of the barrel at the centre or bung hole section. This would be a fairly satisfactory measure, so long as the barrels were of the same general shape and length, but it would manifestly be wholly an unsatisfactory measure with carks of different lengths and varying shapes. A cask, for example, built in the form of a long tube (such as the tanks employed to ship gas under pressure) would have to have the length as well as the diameter stated. Casks or barrels built in the shape of the English milk-cans would present another variation requiring special treatment, and so on. Ultimately, some other measure than the convenient and simple diameter dimension of the cask would have to be adopted, such as the gallons or cubic feet of the liquid the cask would hold, or, to be more exact, the gallons of some given liquid, *e.g.*, water at a specific density. In this analogy, the diameter of the cask would correspond to candlepower, and the gallons to the Lumen.

The Lumen Defined and Explained.

The Lumen is strictly defined as the unit of luminous flux. Luminous flux is radiant power evaluated according to its visibility, *i.e.*, its capacity to produce the sensation of light. This sounds somewhat formidable, but so does a full and correct definition of most terms or words. I daresay the full definition of a kilogram would dismay numbers who employ it constantly in buying and selling.

Briefly stated, the Lumen is the unit of the quantity of light flowing from a lamp or luminous source.

The value established for the Lumen is the amount of light from a unit source falling upon a unit surface, all points of which are at a unit distance from the source. Let us be more specific, and assume a source of one spherical English candle, and place this at the centre of a sphere of one foot radius. It follows that the Lumen is the amount of light which is falling upon one square foot of surface of this sphere. The total area of a sphere with one foot radius is 4π or 12·57 square feet. As each square foot represents a value of one Lumen there will therefore be 12·57 Lumens on the total sphere. It follows from this that the lighting value in Lumens of any lamp or luminous source is obtained by multiplying the mean spherical candlepower of the source by this figure, 12.57.

It follows from the above definition that a Lumen will give an intensity of one foot candle over an area of one square foot. The average illumination at all points of our unit sphere mentioned above will be one foot candle.

We thus have the total light output of the lamp definitely measured by the Lumens, instead of light intensity in some one direction by candlepower. We have the illumination values measured by Lumens per square foot. As each Lumen corresponds to one foot candle per square foot, the term " foot candles per square foot per watt " (the expression for efficiency of illumination) becomes more simply " Lumens per watt." We also have the efficiency of the lamp clearly and fully measured by Lumens per watt, instead of watts per candle. The brightness of a surface, either " self-luminious " and radiating light, or made luminous

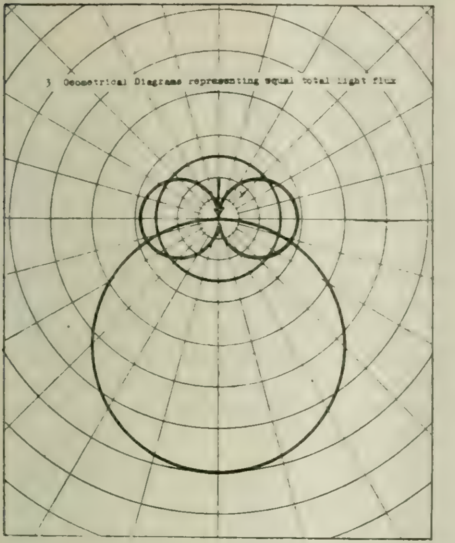

FIG. 7.—Ideal Curves, showing same total light flux. Each curve expresses equal illuminating value (the same total lumens) but apparently very different candlepower values.

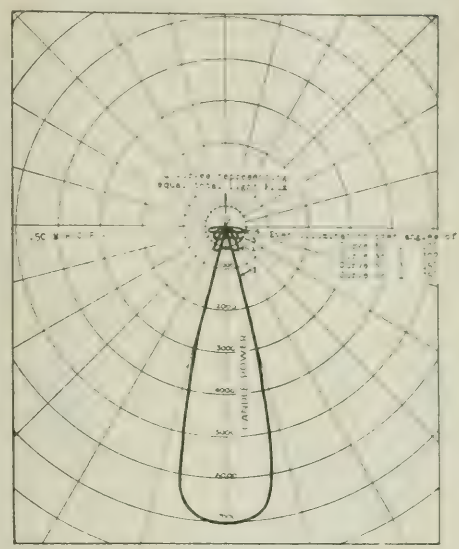

FIG. 9.—Diagram showing how, in an extreme case, the same total light flux may be distributed so as to show very misleading apparent values of candlepower.

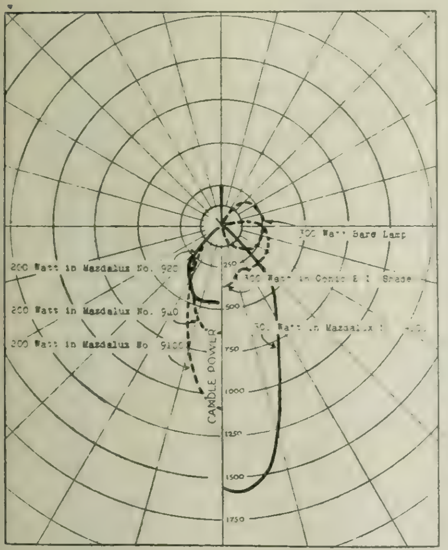

FIG. 8. Apparent variation in candlepower from a 300 watt Lamp, through use of various reflectors.

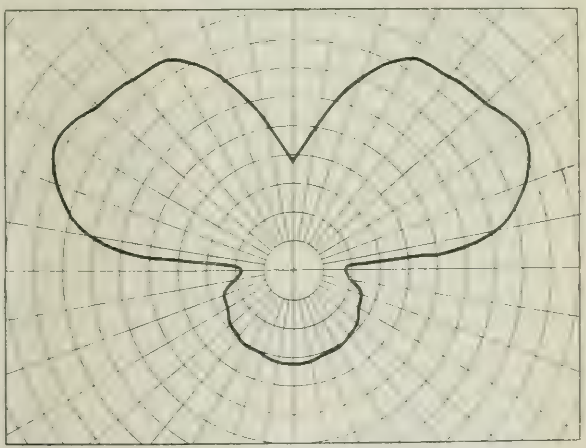

FIG. 10.—Light distribution from Veluria Hemisphere, showing the complex character of light distribution with modern lighting equipment.

by reflected light, may be preferably expressed in terms of Lumens per sq. ft. or per sq. cm. instead of candles per square foot or per square inch or in "equivalent foot-candles." Thus the Lumen is an all-round term of general application in lighting work.

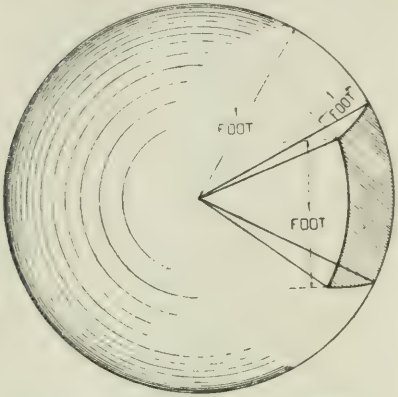

FIG. 12.—Graphical Representation of the Lumen.

In Fig. 12 is given a graphical representation of the Lumen shown by means of the unit sphere.

It may be a help towards a clear conception of the meaning of candlepower, illumination and flux of light if the relations between these quantities are expressed mathematically.

Assume therefore that the candlepower is represented by I, the flux of light in Lumens by F, the illumination in foot-candles by E, that the distance from the source to the surface illuminated is R, and the angle at which the rays strike the surface is θ, and the area of this surface S.

Now if A be the solid angle subtended at the surface by the source, we have :—

$$F = I \times A \quad = \quad \frac{I \times S \cos\theta}{R^2}$$

$$\left[\begin{array}{l}\text{Flux of Light} = \\ \quad \text{Candlepower} \times \text{Solid Angle}\end{array} = \frac{\text{Candlepower} \times \text{Area}}{(\text{Distance})^2}\right]$$

$$E = F\ S\cos\theta = \frac{I}{R^2}$$

$$\left[\text{Illumination} = \frac{\text{Flux}}{\text{Area}} = \frac{\text{Candlepower}}{(\text{Distance})^2}\right]$$

If we desire to obtain the *total flux* emitted by a source we must multiply the mean spherical candlepower by the entire solid angle over which it operates, which is, in circular measure, $4\pi = 12{\cdot}57$ approx.

Whence the relation :—

Flux of Light = Mean Sph. C.P. $\times 4\pi$.

It will be observed that the Lumen is essentially a quantity denoting rate of flow of energy in the form of light, and is therefore analogous to, and of the same dimensions as watts. In order to obtain the total light-output during a given interval of time, analogous to energy, we must multiply the flux of light by the period during which it operates. The output of light from a source in a given time is therefore conveniently expressed in lumen-seconds or lumen-hours.

Lumen *versus* Spherical Candlepower.

In the previous discussions on this subject, the deficiencies of candlepower were admitted by almost every one discussing the matter. Many, however, seem to have been of the opinion that the adoption of "mean spherical candlepower" would solve the difficulties, and they were therefore not favourable to the adoption of the Lumen. It becomes desirable, therefore, to consider the merits of mean spherical candlepower as compared to the Lumen.

Mean spherical candlepower as a unit is best described as a mouthful. The term is a compound of a number of words, generally expressed by the letters "M.S.C.P.," which will always be more or less cryptic to most people, and can hardly be called a practical expression for a unit. If the unit of luminous value was to be the mean spherical candlepower, we would have to adopt some new term or name to call it by. It is too cumbersome an expression as it stands, and would not serve. Another objection to mean spherical candlepower is its similarity to the expression "mean horizontal candlepower" (M.H.C.P.). It perpetuates the term "candlepower" with the inheritances associated with this term, and is therefore sure to result in confusion, not only in the minds of laymen, but of engineers as well.

It is certainly much better, in adopting the flux idea for expressing luminous output, to entirely drop the term "candlepower" in any expression for this unit, and substitute an entirely new term, such as the Lumen. In this way, we cut loose from all the previous deficiencies and misconceptions associated with the term "candlepower" as set forth herein. It may be somewhat difficult to adapt every one's mind to the use of the new term "Lumen," but such an obstacle would be far easier to overcome, in the writer's opinion, than it will be to instil in everybody's mind an intelligent understanding and use of the terms "mean horizontal," "mean spherical," "tip end candlepower," etc.

The conception of mean spherical candlepower does not lend itself readily to express the volume of light in any given zone or section of space surrounding a luminous source. It is difficult, for example, to conceive expressing the amount of light in a 10° zone (beneath a lamp in a reflector as shown in Fig. 13), as so many "mean spherical candlepowers." The conception is perfectly clear, however, when we express the volume of light in these zones in Lumens. The term candlepower has already been allocated to the specification of the intensity of light in different directions. It is therefore far better not to repeat this term (in the form of mean spherical candlepower) to indicate the summation of the light yielded in a number of directions, but to indicate this quantity, the flux of light, by an entirely new unit, the Lumen. The practical reasons mentioned above furnish strong grounds, in the writer's opinion, for the adoption of an entirely new term or unit instead of the cumbersome term and conception of "mean spherical candlepower."

Again, mean spherical candlepower does not lend itself to expression illumination values as the Lumen does. We have noted above that the Lumens per square foot can be used as a unit of illumination intensities as a substitutes for the express sion "foot candles," and that "Lumens per watt" is a simple expression for the efficiency of illumination, as a substitute for the present term "foot candles per square foot per watt."

If the majority of engineers are clearly in agreement, as previous discussions show, as to the desirability of some more comprehensive unit, such as the "mean spherical candlepower," surely it is a small matter as to whether we go a step further, and have an entirely new unit, but with a more simple name; one freed from any limiting preconceptions and conditions associated with candlepower; one which is scientifically correct and properly co-ordinated in a complete system of lighting units, and one therefore more fully and better qualified to express clearly and definitely the conception of light as a flux—the fundamental idea where a radiation such as light is concerned.

I think the conclusions are unavoidably in favour of the Lumen, and that inevitably the merits of the Lumen will ultimately force its adoption, in spite of individual opinions to the contrary. It therefore seems desirable that the way should be opened for the free use of this new unit, and its adoption promoted in every way by the full co-operation of manufacturers of lighting appliances and illuminating engineers generally.

I am happy to say that this programme has already been put into effect by a number of the leading electric lamp manufacturers in Great Britain, as well as by the Holophane Company, who are adopting the plan of expressing their luminous ratings in Lumens.

The hesitation or fear that many express about adopting or popularising a new term seem more or less exaggerated to the writer. No doubt these fears arise on every similar occasion, but the industry and the public having lived through and become accustomed to the electrical terms of kilowatts, amperes, and volts, not to mention others in connection with other industries, and this same public will find no serious difficulty in sooner or later thinking and expressing luminous values in Lumens.

I recognise that it is desirable to define the Lumen with the greatest possible precision from a scientific standpoint, and also to take measures to render the term intelligible to the general public. But, from a practical standpoint, the public are less concerned with exact scientific definition of a quantity than with the visualising, in practice, of what it represents. For example it is much more important that a man who is adopting the metric system should appreciate that a kilogram is approximately equal to 2·2 lbs., and should thus form a clear idea of the weight of a kilogram, than that he should be informed as to the exact way in which this unit is defined and preserved.

For a time, as in the case of all similar transitions, people's minds will think in candlepowers as well as Lumens, but sooner or later Lumens will be used more or less entirely as the unit, in the same way that the kilogramme has displaced the former units of weight used in countries where the metric system has been adopted.

In the end, such a change will have many benefits in simplifying the whole subject of illumination. We have at the present time, in the measurement of light and illumination, three distinct units — candlepower, mean spherical candlepower, and foot candles. The Lumen gives us one unit and term to serve generally in place of all these units.* The Lumen expresses the luminous output for all conditions in place of candlepower, mean spherical candlepower, etc. The Lumens per square foot expresses the intensity of illumination and brightness in place of foot-candles, and the Lumens per watt with electricity, or per cubic foot for gas expresses the efficiency of a luminous source, taking all conditions and variations into consideration affecting the shape of the burner or the equipment of the lamp.

Practical Employment of the Lumen.

The adoption of the term "Lumen" and familiarity therewith makes it easy to lay out lighting systems. In employing Lumens in practical illuminating problems, engineers have recourse to what is known as the utilisation efficiency factor, which expresses the efficiency of utilisation of the light. This is nothing more than the percentage of the total amount of Lumens given by a luminous source which is made available upon the working plane or illumination area considered. These utilisation efficiencies vary from 60 per cent. to 70 per cent. down to as low as 15 per cent. to 20 per cent. They depend essentially on the colour and character of walls and ceiling, and amount of light reflected therefrom. They are determined for the different characters of interiors and for different systems of lighting, and when determined are tabulated in convenient table form for use.

In lighting a room, the area of the room in square feet is multiplied by the intensity desired in foot-candles. This at once gives the net Lumens required. To find the total Lumens required from the lamps, we divide the net Lumens by the utilisation efficiency or factor decimally expressed. We then have the total Lumens which the lamps must give, and by reference to a table of Lumen values for the various sizes of lamps, we can select the most suitable size to accord with the desired number of points to be fixed, or we modify the number of points to accord with the Lumen value of some desired size of lamp. The simple equation for such work is :-

$$\frac{\text{Floor area in sq. feet} \times \text{Intensity in foot-candles}}{\text{Utilisation efficiency as a decimal} \times \text{Lumens per lamp}} = \text{Number of lamps.}$$

This is an example of the simple problem, but the calculation for side walls and more complicated cases may be worked out in a similar way.

Use of the Lumen in Evaluating Polar Curves of Light Distribution.

A very interesting application of the Lumen arises in connection with the interpretation of polar curves of light distribution in candlepower. Such curves are necessary and useful for showing how the flux of light from a lamp, either alone or in combination with a suitable globe or reflector, varies in different directions. The adoption of rating in Lumens does not imply that these curves can be dispensed with, but on the contrary is an aid in their interpretation. The candlepower distribution curve merely expresses the variation in intensity in a given plane, but gives no immediate conception of the volume of light in the total flux, *i.e.*, the "shower of light" from the source investigated. We have already seen in Figs. 7, 8, and 9 how confusing such curves may be if applied to compare the total flux of light from different sources. The true basis of comparison only becomes apparent when we employ the Rousseau curve or similar trigonometrical constructions and measure up the resulting diagram with a planimeter; whereas if sheets giving the values of the Lumens in each zone are presented we have a proper means of comparing not only the total flux of light in each case, but the true proportions of this flux emitted over different angles.

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* I say generally because candlepower-values will still be used to express intensity in different directions. Because we recognise that pressure is not a satisfactory basis of comparing the capacity of pumps, it does not follow that the pressure in pumps should not be studied and stated.

Fig. 14 shows such a photometric record sheet of a reflector and lamp, with values of light flux as expressed in Lumens. A curve of light distribution for this unit is given in Fig. 13. A study of this clearly shows the very definite and complete expression of luminous output for the various zones beneath the lamp, which permits of accurate comparisons between different reflectors and light distribution curves. As an instance of this, we have in Figs. 13 and 15, with their corresponding tables shown in Figs. 14 and 16, two reflectors giving entirely different distribution curves from the same size of lamp—100 watts. These comparisons are further complicated by the curves being drawn to different scales. The Lumen values, however, as shown in the tables for each reflector, present an exact comparison for each and every angular position and zone and show that the apparent difference which appears to the eye by comparison of the two curves does not really exist in actual light flux.

The table in Fig. 17 presents a list of standard vacuum type and half-watt type metal filament lamps, and gives the efficiencies at present supplied in Great Britain. For the vacuum type lamps, it is given on the present basis—watts per candle, and on the new basis Lumens per watt. For the half-watt type lamps, the efficiency is given on the new basis only—Lumens per watt. The half-watt type lamp has a much higher reduction factor of horizontal to total spherical candlepower than the ordinary vacuum type lamp, so that the half-watt type lamp gives considerably greater total flux of light with the same horizontal candlepower than the vacuum type lamp does. This emphasises the use of the Lumen rating and Lumen per watt efficiency basis for the half-watt type lamp. This table also gives full Lumen values for each size of lamp, and the corresponding Lumen values at various utilisation efficiencies as shown.

It has been argued that the Lumen values are invariably derived from the measurement of candlepower in practice; even were this the case it would not prejudice the Lumen as a method of presenting illuminating power, but as a matter of fact it is also possible to make measurements direct in Lumens.

Electric lamps are now most satisfactorily and readily photometered by the use of the sphere photometer. The use of this form of photometer is rapidly growing, and simplifies the problem of measuring the total flux of light from an illuminant.

The lamp is inserted in the centre of an enclosing sphere, and the total light flux given out by the lamp is measured in one reading. This reading can be directly measured in Lumens without having recourse to candlepower values.

It is, however, convenient and natural to convert candlepower values into Lumen values as results are at present almost invariably available in terms of candlepower. The ordinary metal filament (vacuum type) lamp gives a Lumen value about ten times its candlepower (mean horizontal) value. This, a 16 c.p. lamp, gives 160 Lumens, a 100 c.p. lamp, 1000 Lumens, &c.*

I have advocated the adoption of the Lumen and supported its case solely on its merits, and I firmly believe that these merits will prevail and ultimately establish this unit in practice. I have not referred to the endorsement of the Lumen in other countries, but it is interesting to know that it has received the endorse-

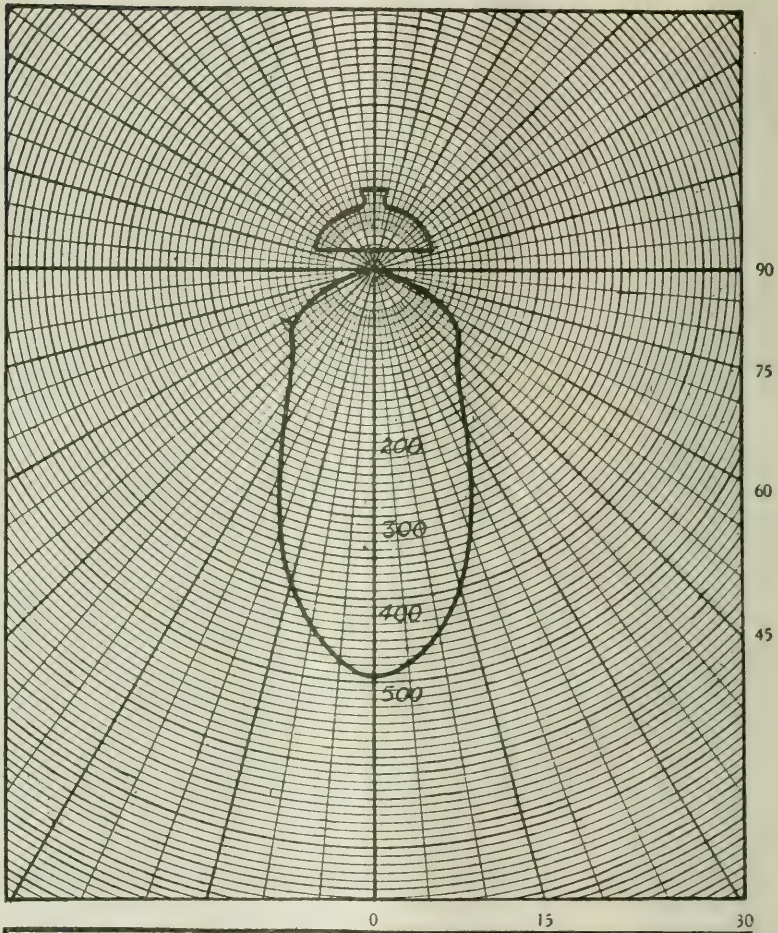
---

* This ratio of 10 between the value in Lumens and the mean horizontal candlepower is derived as follows :—

The mean spherical candlepower of the ordinary vacuum metal filament lamp is 78 per cent. to 79 per cent. of the mean horizontal candlepower. Therefore the flux in Lumens is $12{\cdot}57 \times 0{\cdot}79 = 9{\cdot}94$, or practically ten times the mean horizontal candlepower.

Reflector No. 710

Photometric Curve Sheet



NOTE.—When 1 division equals 1 Cp. one inch equals 20 lumens, measured as horizontal distance from nadir to center of 10 degree zones.

Angle	Candle Power Lamp & Refl.	Candle Power Bare Lamp	Angle	Candle Power Lamp & Refl	Candle Power Bare Lamp
0°	492.0		90°		
5°	478.0		95°		
15°	393.0		105°		
25°	275.0		115°		
35°	183.3		125°		
40°			135°		
45°	141.0		145°		
55°	122.0		155°		
65°	67.3		165°		
75°	12.6		175°		
85°	4.3		180°		

	Lamp and Reflector			Bare Lamp		
Zone . . .	0-60°	0-90°	0-180°	0-60°	0-90°	0-180°
Lumens . .	617.3	702.0				866.0

Reflector X·Ray N° 710 Holder Form "O".

Lamp Mozda Clear S-30-A Watts 100.0 Volts 110.0

Plotted by Test No. DW·1

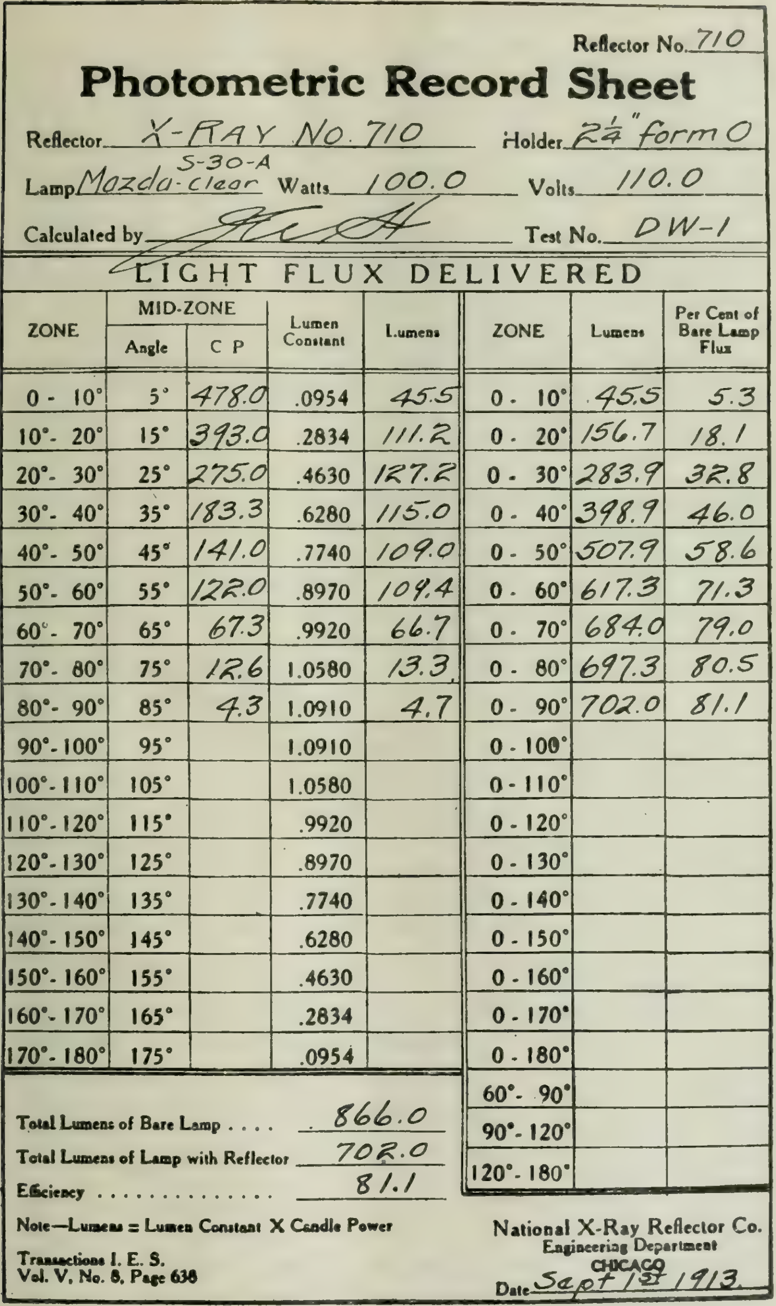
National X-Ray Reflector Co.
Engineering Department
CHICAGO

W.P.C. 1.13

Date Sept: 1 1913.

FIG. 13.—Photometric Curve Sheet (Light Distribution Curve) of Lamp and Reflector.

To be used with Photometric Record Sheet (Fig. 14), showing how Lumen values are employed for such curves to evaluate clearly and accurately the light flux in each section or angular zone of the curve, and thus enable accurate comparisons to be made with any other distribution curve, such as that shown in Fig. 15 (and Record Sheet, Fig. 16).



Reflector No. 710

Photometric Record Sheet

Reflector X-RAY NO. 710 Holder $2\frac{1}{4}$" form O

Lamp Mozda-clear S-30-A Watts 100.0 Volts 110.0

Calculated by Test No. DW-1

LIGHT FLUX DELIVERED

ZONE	MID-ZONE		Lumen Constant	Lumens	ZONE	Lumens	Per Cent of Bare Lamp Flux
	Angle	C P					
0 - 10°	5°	478.0	.0954	45.5	0 - 10°	45.5	5.3
10°- 20°	15°	393.0	.2834	111.2	0 - 20°	156.7	18.1
20°- 30°	25°	275.0	.4630	127.2	0 - 30°	283.9	32.8
30°- 40°	35°	183.3	.6280	115.0	0 - 40°	398.9	46.0
40°- 50°	45°	141.0	.7740	109.0	0 - 50°	507.9	58.6
50°- 60°	55°	122.0	.8970	109.4	0 - 60°	617.3	71.3
60°- 70°	65°	67.3	.9920	66.7	0 - 70°	684.0	79.0
70°- 80°	75°	12.6	1.0580	13.3	0 - 80°	697.3	80.5
80°- 90°	85°	4.3	1.0910	4.7	0 - 90°	702.0	81.1
90°-100°	95°		1.0910		0 - 100°		
100°-110°	105°		1.0580		0 - 110°		
110°-120°	115°		.9920		0 - 120°		
120°-130°	125°		.8970		0 - 130°		
130°-140°	135°		.7740		0 - 140°		
140°-150°	145°		.6280		0 - 150°		
150°-160°	155°		.4630		0 - 160°		
160°-170°	165°		.2834		0 - 170°		
170°-180°	175°		.0954		0 - 180°		
					60°- 90°		
					90°- 120°		
					120°- 180°		

Total Lumens of Bare Lamp 866.0

Total Lumens of Lamp with Reflector 702.0

Efficiency 81.1

Note—Lumens = Lumen Constant X Candle Power

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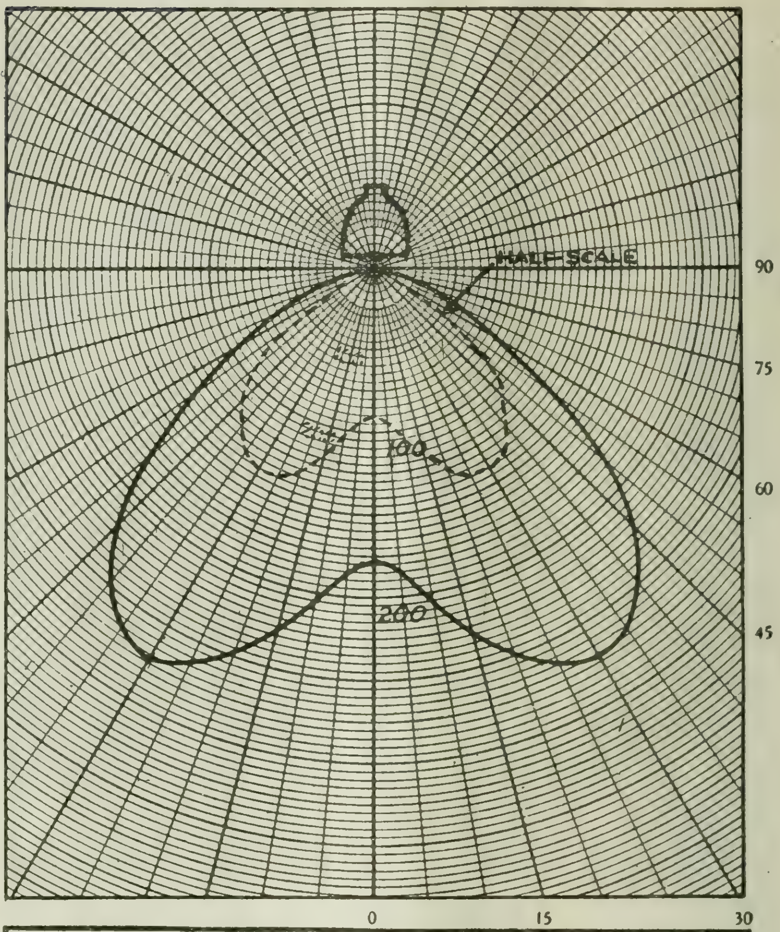
National X-Ray Reflector Co.
Engineering Department
CHICAGO
Date Sept 1st 1913.

FIG. 14.—Table of Values, showing how Lumens are employed to express accurately the light flux delivered in each section or angular zone of the light distribution curve of lamp and reflector (Fig. 13).

Reflector No. 565.

Photometric Curve Sheet



NOTE—When 1 division equals 1 Cp. one inch equals 20 lumens; measured as horizontal distance from nadir to center of 10 degree zones

Angle	Candle Power Lamp & Refl.	Candle Power Bare Lamp	Angle	Candle Power Lamp & Refl	Candle Power Bare Lamp
0°	177		90°		
5°	186		95°		
15°	230		105°		
25°	264		115°		
35°	266		125°		
40°			135°		
45°	222		145°		
55°	132		155°		
65°	58.5		165°		
75°	23.3		175°		
85°			180°		

	Lamp and Reflector			Bare Lamp		
Zone . . .	0-60°	0-90°	0-180°	0-60°	0-90°	0-180°
Lumens . .	662	745	745			971

Reflector X-Ray No. 565. Holder 2¼" Form "H".
Lamp Clear Mazda S-30-A Watts 100.0 Volts 110.0
Plotted by J. A. Test No. G-1.

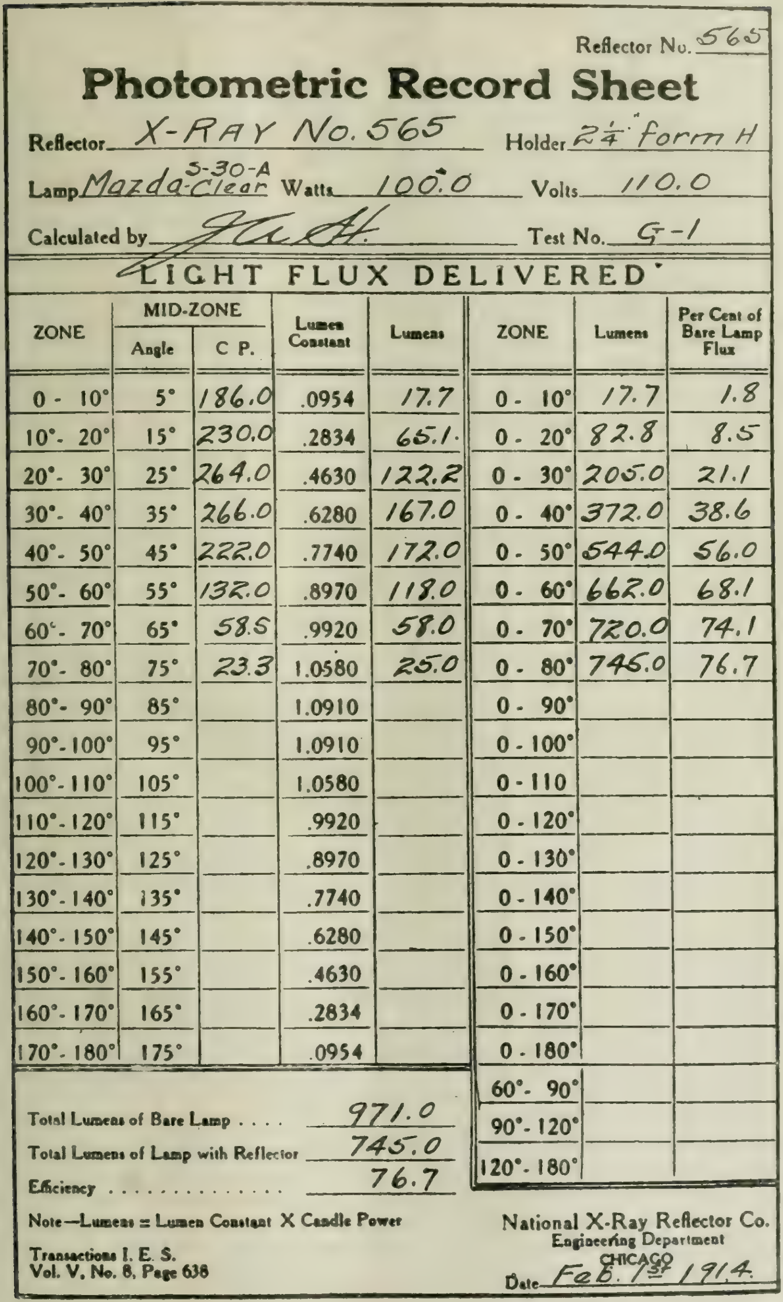
National X-Ray Reflector Co.
Engineering Department
CHICAGO

W.P.C -1.02

Date Feb. 1, 1914.

FIG. 15.—Photometric Curve Sheet (Light Distribution Curve of Lamp and Reflector. (Dotted curve same scale as curve in Fig. 13).

To be used with Photometric Record Sheet (Fig. 16), showing how Lumen Values are employed for such curves to evaluate clearly and accurately the light flux in each section or angular zone, and enable definite comparisons to be made with ther distribution curves, such as Fig. 13 (and Record Sheet Fig. 14).



Reflector No. 565

Photometric Record Sheet

Reflector X-RAY No. 565 Holder 2¼" form H

Lamp Mazda-Clear 5-30-A Watts 100.0 Volts 110.0

Calculated by Test No. G-1

LIGHT FLUX DELIVERED

ZONE	MID-ZONE		Lumen Constant	Lumens	ZONE	Lumens	Per Cent of Bare Lamp Flux
	Angle	C P.					
0 - 10°	5°	186.0	.0954	17.7	0 - 10°	17.7	1.8
10°- 20°	15°	230.0	.2834	65.1	0 - 20°	82.8	8.5
20°- 30°	25°	264.0	.4630	122.2	0 - 30°	205.0	21.1
30°- 40°	35°	266.0	.6280	167.0	0 - 40°	372.0	38.6
40°- 50°	45°	222.0	.7740	172.0	0 - 50°	544.0	56.0
50°- 60°	55°	132.0	.8970	118.0	0 - 60°	662.0	68.1
60°- 70°	65°	58.5	.9920	58.0	0 - 70°	720.0	74.1
70°- 80°	75°	23.3	1.0580	25.0	0 - 80°	745.0	76.7
80°- 90°	85°		1.0910		0 - 90°		
90°-100°	95°		1.0910		0 - 100°		
100°-110°	105°		1.0580		0 - 110		
110°-120°	115°		.9920		0 - 120°		
120°-130°	125°		.8970		0 - 130°		
130°-140°	135°		.7740		0 - 140°		
140°-150°	145°		.6280		0 - 150°		
150°-160°	155°		.4630		0 - 160°		
160°-170°	165°		.2834		0 - 170°		
170°-180°	175°		.0954		0 - 180°		

ZONE	Lumens	Per Cent of Bare Lamp Flux
60°- 90°		
90°- 120°		
120°- 180°		

Total Lumens of Bare Lamp 971.0

Total Lumens of Lamp with Reflector 745.0

Efficiency 76.7

Note—Lumens = Lumen Constant X Candle Power

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National X-Ray Reflector Co.
Engineering Department
CHICAGO
Date Feb. 1st 1914.

FIG. 16.—Table of Values, showing how Lumens are employed to express accurately the light flux delivered in each section or angular zone of the light distribution curve of Lamp and Reflector (Fig. 15).

FIUGRE 17.

LUMEN DATA FOR METAL FILAMENT (TUNGSTEN) LAMPS, OF SIZES AND EFFICIENCY STANDARDS IN GREAT BRITAIN, JANUARY, 1917. VOLTAGE CLASS, 100 – 130.

	Size of Lamp in Total Watts	Efficiency		Initial Lumen Values at various Utilisation Efficiencies.																
		Watts per Mean Horiz. C.P.	Lumens per Watt	Total 1.00	0.65	0 60	0.55	0.50	0.45	0.40	0.36	0·34	0·32	0.30	0.28	0.26	0.24	0 22	0.20	0.15
Vacuum type	20	1·20	8·1	163	105·9	97 8	89·6	81·5	73·3	65 2	58·6	55·4	52·1	48·9	45·6	42·3	39·1	35·8	32·6	24·4
	30	1 15	8·5	255	165.7	153	140·2	127·5	114·7	102	91·8	86·7	81·6	76·5	71·4	66·3	61·2	56·1	51·0	38·2
	40	1 15	8 4	341	221·6	204·6	187·5	170·5	153·4	136·4	122·7	115·9	109·1	102 3	95·4	88·6	81·8	75·0	68·2	51·1
	60	1·10	8·9	535	347.7	321	294·2	267·5	240 7	214	192·6	181·9	171·2	160·5	149·8	139 1	128 4	117·7	107	80·0
	100	1 05	9·3	930	604·5	558	511·5	465	418·5	372	334·8	316·2	297·6	279	260·4	241·8	223·2	204·6	186	139·5
	150	1·0	9 8	1470	955·5	882	808·5	735	661·5	588	529·2	499·8	470·4	441	411·6	382 2	352·8	323·4	294	220·5
Half-Watt type	100	—	12·5	1250	812·5	750	687·5	625	562·5	500	450	425	400	375	350	325	300	275	250	187·5
	150	—	13·4	2010	1306·5	1206	1105·5	1005	904·5	804	723·6	683·4	643·2	603	562·8	522·6	482·4	442·2	402	301·5
	200	—	14·0	2795	1816·7	1677	1537·2	1397·5	1257·7	1118	1006·2	950·3	894·4	838·5	782·6	726·7	670·8	614·9	559	419·2
	300	-	15·3	4600	2990	2760	2530	2300	2070	1840	1656	1564	1472	1380	1288	1196	1104	1012	920	690
	500		16·12	8060	5239	4836	4433	4030	3627	3224	2901 6	2740 4	2579·2	2418	2256 8	2095·6	1934·4	1773·2	1612	1209
	1000	-	18 0	18000	11700	10800	9900	9000	8100	7200	6480	6120	5760	5400	5040	4680	4320	3960	3600	2700
	1500	—	18 0	27000	17550	16200	14850	13500	12150	10800	9720	9180	8640	8100	7560	7020	6480	5940	5400	4050

ment of the American Illuminating Engineering Society, of the Association of the Edison Illuminating Companies and of the National Electric Light Association, is being employed in regular practice in the rating of electric lamps. The Lumen of is Continental origin, and was originally proposed by Prof. Blondel, of Paris.

In view of the Lumen's merits as an all-round term for lighting practice, and the general situation as described herein, the writer hopes that all manufacturers of lamps and lighting appliances, supply companies, both gas and electric, and all those having to do with light and illumination in Great Britain, will co-operate to assist in the inttroducion and popularisation of the Lumen.

This programme would, for the time being, simply follow the plan of the principal electric lamp manufacturers mentioned above, of stating in addition to the candlepower values the values of their lamps in Lumens. No better work could be undertaken by this Society than assisting to this same end, particularly in preparing and publishing a monograph or pamphlet describing the Lumen in clear, popular language, and illustrating by numerous examples its meaning, its value, and its application to practical lighting problems in various ways.

DISCUSSION.

The CHAIRMAN, in opening the discussion, referred to the need for a good and brief definition of the Lumen.

Mr. S. H. CALLOW: I do not think I can add very much to the remarks of Professor Morris and Mr. Willcox; but I feel strongly that the old method of rating illuminants by horizontal candlepower is inadequate to meet present-day conditions. The rating of electric lamps by horizontal candlepower dates from the early days of carbon filament lamps, when all filaments were practically uniform in shape, and the maximum candlepower was given in horizontal direction.

This is not so to-day, either in the case of many forms of electric units or gas units; and therefore the rating of such units in horizontal candlepower does not give an adequate comparison of one form of unit with another. After all is said and done, when a consumer purchases any form of illuminant, the most important point is the total quantity of light he is going to obtain from it, and not the maximum candlepower which it may give at one particular angle.

The present method of rating also lends itself to deception. For instance, it is obviously quite easy to design a vacuum type metal filament lamp which will give a candlepower equal to twice the value of the watts consumed in one given direction. Such a lamp might then be called a "half watt" lamp, although not gas filled, and having an efficiency in watts per mean spherical candlepower only equal to that of the ordinary vacuum type lamp. Such lamps have in the past been foisted on the public as "half watt" type lamps. If they had been rated in spherical candlepower or Lumens this could not have been done.

I think it is therefore fairly obvious that a change in rating is not only desirable, but necessary. If we are to take one step from horizontal to mean spherical candlepower I think it preferable to take two, and pass on to rating in Lumens, which is the most convenient unit.

Mr. J. G. CLARK, speaking from the gas standpoint, said that he would like to testify to the usefulness of the Lumen from the practical point of view, but he was a little bit uneasy about its general adoption as a commercial unit.

The rating of lamps resolved itself into two portions, the scientific and the commercial. The former hardly needed our present attention, but some speakers seemed to have the impression that the luminous value of a lamp in Lumens was easily obtainable by simply putting it in an Ulbricht sphere and getting the figure directly.

This, however, ignored distribution entirely, and if we did anything to hide the effect of distribution we should be in a bigger hole than ever. It was very nice to have in a single figure the total amount of light marked on a lamp, but if we did not know where the light was going this was not a very exact guide as to the best form of lamp to be used. For instance there might be two forms of lamps, each with the same flux of light in Lumens but one of them might give 60 per cent. of its light in an upward direction and 40 per cent. in a downward direction whilst the other might give the reverse. In all direct lighting systems practically all the light was delivered on the downward direction by the aid of reflectors, and as all these latter were not of the same efficiency this fact introduced the complication that two lamps of the same indicated efficiency in Lumens were not equal when fitted with globes and reflectors. Of two lamps the one which gave the greater quantity of light in the downward direction and the least to the reflector would show up to the best advantage, and in this way the Lumen might be a little misleading. Professor Morris had pointed out that to make the best use of the Lumen we should have to specify Lumen values in specific zones, but this brought us back again to the distribution curve, because in order to get zonal values it would be necessary to get the polar curve of the lamp and practically it did not take us very much further than we are now.

On the whole he could not help feeling that the use of the term Lumen was just as likely to be unsatisfactory as the terms we already had, and, after all, lighting problems seemed to be in need of a good deal of education of the general public. If the Council could, through the educational institutions, make lighting as a practical problem a more general subject of study the question would solve itself, because no man who knew anything about lighting would be deceived by polar curves which seemed to have a bigger radius in one direction than another.

Mr. A. BLOK said that if it was, in the opinion of the meeting desirable, that the Lumen should be adopted as a basis for rating lamps, the Society must not rest content until it had made the term intelligible to the people concerned. The substitution of a new unit for an existing one was a big undertaking and it was necessary to show a clear case for it. The paper presented before the Society by Mr. Clinton in March, 1914,* showed what a reliable and powerful tool the Lumen was to illuminating engineers, and if the Society, after the present discussion, decided that its adoption was a desirable thing, then he hoped that the Council would consider Mr. Willcox's suggestion of setting up some proper machinery for disseminating what might be called "lumen knowledge." An obvious course would be for the Society, as a neutral platform, to draw up a pamphlet in simple terms containing a number of worked-out examples which would be of use at any rate to the average contractor, if not to the ordinary users of lamps. The average contractor would probably be puzzled if the lamps were marked in Lumens unless he were clearly told what the Lumen is, and the wide distribution of a simple explanatory pamphlet bearing the stamp of authority of the Society would do a great deal towards establishing the Lumen in the lighting industry. Without a definite campaign of this sort he thought that there was little chance of much good being done.

Dr. L. RABINOVITCH, while recognising the advantages of the Lumen from a scientific standpoint, thought that the larger values it implied would be a source of confusion to the general public, and that the great variations in the distribution of light due to various shades and reflectors would make explanation difficult.

It appeared to him, as a lamp maker, that while the measurement of horizontal candlepower was an easy process, the determination and guarantee of a definite number of Lumens would be a more complicated process.

Would it not be possible to find a compromise between the two methods of rating by providing fuller information regarding the candlepower in different directions? Dr. Fleming had demonstrated that in order to convert mean horizontal candlepower into mean spherical candlepower a coefficient of 0·78 was necessary in the case of carbon filament lamps and a somewhat different figure in the case of ordinary tungsten lamps with straight filaments (which formed much the larger proportion of lamps manufactured). If lamp makers would make a practice of mentioning such coefficients in their catalogues he thought this would go far to satisfy the needs of the illuminating engineer.

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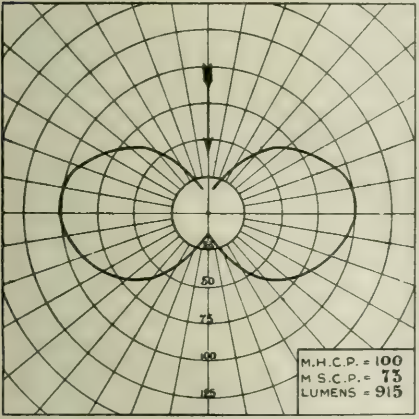
* *Illum. Eng.*, Vol. VII., p. 189, April 1914.

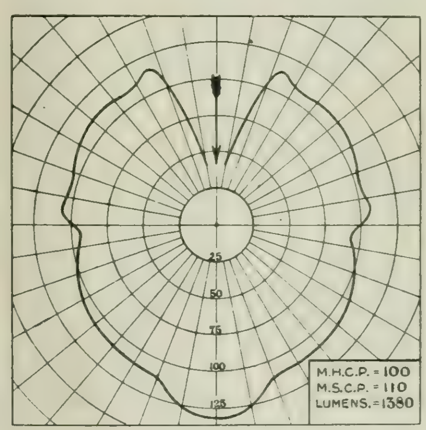
Mr. G. CAMPBELL supported the use of the Lumen and expressed regret that Mr. Clark did not appear to be in full agreement with the proposition, because it would be a good thing if representatives of gas and electric lighting could come to a common understanding on this matter.

The present was a good opportunity for making the change which might not occur again. He had never found it very difficult to explain the use of the Lumen, but the suggestion that the Society should help the movement was most important. Without that support the discussion would be of relatively little value. If the members of the Tungsten Lamp Association would agree to mark their lamps in Lumens and Watts, this would be a very considerable step forward.



STRAIGHT FILAMENT TUNGSTEN LAMP.
PLOTTED TO M H.C.P.=100.

FIG. 1.



HELICAL FILAMENT TUNGSTEN LAMP.
PLOTTED TO M.H.C P.=100.

E STROUD.

FIG. 2.

Mr. E. STROUD: From the discussion many of the previous speakers seem to imply that if the Lumen were adopted as a unit it would no longer be necessary to consider candlepower in a given direction, polar curves, illumination curves and all calculations necessary for illumination problems. This, of course, is entirely fallacious, as one would still have to consider all these factors, there being no such simple way out of a subject which requires careful and long study.

I understand that the real question before us to-night is to discuss the Lumen as a desirable rating for lamps.

The present rating, as generally meant, is in terms of horizontal candlepower, but this is by no means standard, some makers rate by the maximum candlepower whatever the direction, and some even rate lamps at the maximum candlepower when equipped with reflectors.

The resultant illumination does not depend upon the rated candlepower, but depends upon the equipment of the installation.

It is possible to obtain as much or more illumination for a specific purpose, with a 25 c.p. lamp properly equipped than with a 100 c.p. lamp badly employed.

Therefore, regarding the correct rating of lamps, I should like you to consider the purpose for which the output rating is of use.

The output rating is required :—

First.—To obtain the efficiency.

Second.—For the purpose of comparing one lamp with another.

Thirdly.—To give the lighting engineer the *quantity* of light at his disposal.

For each of these purposes it is necessary to know the quantity of light emitted.

To show how inadequate is the rating

by mean horizontal candlepower, I would refer to Figs. 1 and 2.

Figure 1 shows the polar distribution curve of an ordinary straight filament tungsten lamp plotted to m.h.c.p. of 100 c.p.

Figure 2 shows the polar distribution curve of a tungsten lamp with the helical form of filament winding, also plotted to m.h.c.p. of 100 c.p.

The quantity of light or Lumens in the first case are 913, while in the second 1380, *i.e.*, 50 per cent. more light is given by Fig. 2 than Fig. 1, and yet under the old basis these lamps would be rated as equal, *i.e.*, 100 c.p.

One might nearly forgive the maker of the lamp with the helical form of winding so as to justify his goods, if he called it 130 c.p., being the maximum in a downward direction, but where does this lead us? Can we call a 50 c.p. lamp 500 because we equip it with a reflector which concentrates the light to this extent?

Undoubtedly the quantity rating must be adopted sooner or later, and so long as it is not adopted and standardised, so long will the science of illumination be retarded, and doubts be raised as to the exact meaning of a particular specification.

The Lumen rating overcomes all this, it tells exactly how much light is given by a source, irrespective of distribution, which cannot be easily misrepresented.

It then remains for the illuminating engineer to utilise the light available with such equipment as would be most advantageous, so as to obtain the maximum of effect or efficiency for the particular problem in view.

It has been suggested that the total Lumens given by a source is too large a quantity, being 12·57 times the mean spherical candlepower, and likely to cause confusion

On this point I would like to make a suggestion. A 100 m.h.c.p. lamp roughly gives 1000 Lumens. If we had a unit which might be called a "Large Lumen," or "Deka Lumen," which was equal to 10 Lumens, then the change could be effective without undue trouble as the lamp with the old 100 c.p. rating would now be 100 Lumens and the new improved lamps would show their improvement as they deserve.

Communicated:—Mr. Trotter raised the query as to simple definition of the Lumen, As this is rather difficult to define in simple language would it not be better to show at this stage how easy it is to obtain the effective Lumens in a practical case—

Lumens=Foot-candles × sq. ft.?

Therefore, if we have an everage intensity of 3 foot-candles in an area of 100 sq. ft., we have 300 Lumens over that area, from which the efficiency of the installation can easily be derived.

Mr. A. Wise said that it was generally agreed that the misuse of the term "candlepower" necessitated the enforcement of a common basis of comparison between various sources of light. At the same time he felt doubtful whether the adoption of the Lumen, although a useful unit in the hands of the illuminating engineer, would remove such possibilities of misconception.

If the output of a lamp was expressed in Lumens this would give a large and somewhat inconvenient figure and some time would be necessary before the public learned to appreciate the significance of these higher values. When the carbon filament lamp was first put on the market the public were made familiar with the conception of candlepower and adjusted their minds to the idea of 8, 16 and 32 c.p. units. With the advent of the metal filament lamp rating in watts became customary, but even now a considerable section of the public hardly understood what they were calling for when demanding 20, 30 or 40 watt lamps. The introduction of the Lumen would involve yet another change, as people would have to accustom themselves to figures of the order of hundreds and even thousands. If, on the other hand, the value of a lamp were expressed in mean spherical candlepower, anyone desiring to work in Lumens could easily make the conversion by multiplying the necessary factor.

In order to illustrate the distribution of light from lamps it would be necessary to tabulate the Lumens in different zones. Such a table would serve essentially the same purpose as the polar curve, except that it would probably only give figures at intervals of 10 or 15 degrees.

In any case he thought there was a need for a clear definition of the Lumen. In Mr. Willcox's paper several distinct definitions were given and these explanations, while all of them correct, might lead to confusion at first sight.

Mr. C. H. PITMAN thought that while it was difficult to show the light in different directions without a polar curve, for the ordinary public such a curve was not necessary. If the lamp lists gave figures of total Lumens and Lumens per zone and the fittings lists gave conversion figures for particular forms of reflectors it could be ascertained what was the amount of light in the useful direction from the combined lamp and reflector.

The conversion figures would be based on the efficiency of the reflector. Thus a 60-watt lamp giving 490 Lumens used with a distributing reflector having an efficiency of 80 per cent. and having an angle of spread of 126 degrees, would give approximately 390 Lumens in this zone. With regard to evenness of illumination this could always be shown by an illumination curve.

It was in connection with lamps which gave their maximum light at particular angles that the adoption of the Lumen would be of the greatest service, for the buyer would know immediately which was the lamp that best suited his requirements.

Whilst Mr. Stroud's suggestion of bringing the number of Lumens down to a smaller figure by dividing by 10, and using a larger Lumen unit, deserved consideration he thought that a better proposal would be to rate lamps in Lumens per watt, thus arriving at a smaller figure, from which all other terms could be quickly derived.

Mr. J. S. Dow said that since the first discussion on this subject in 1914 he had always felt that, from the scientific standpoint, the Lumen was the best term to adopt, and Mr. Willcox had put the case extremely well. The only question was how far it was practicable to make the ordinary public accept it. The onus of doing so rested largely on the makers of lamps and lighting appliances, and no doubt a little bulletin on the lines suggested would be the first step in the necessary educational campaign. Mr. Willcox and Prof. Morris were right in suggesting that the confusion and misrepresentation arising from statements of the effective light in one direction only were really facilitating by rating in candlepower. A man who produced a lamp in which the light was concentrated mainly in one direction and gave the impression that this was a proper measure of the illuminating power of the lamp as a whole was certainly guilty of misrepresentation; because in the data presented there was no clear indication to the public of the area over which this high local candlepower operated nor of the proportion which this formed of the whole output of light. The series of curves shown by Mr. Willcox demonstrated very clearly how the impression conveyed to the uninitiated by polar curves of candlepower might be quite misleading. Such curves are useful in the hands of the expert and will continue to be so, but the man in the street, to whom the Rousseau construction is unintelligible, is very apt to misinterpret them.

Now when the illuminating powers are tabulated in terms of Lumens the value given for any particular zone takes into account the area over which the candlepower is emitted. The added values in each zone give the total flux of light and the proportion of light concentrated at different angles is made evident. In these circumstances it might be quite legitimate to point out that with a certain form of lighting unit a larger proportion of light was directed in a useful direction; at all events the scope for misrepresentation was much less.

Mr. Dow also pointed out that the conception of the Lumen was essential to many calculations with beams of light, such as those emitted from searchlights and projection apparatus. It was only by comparing the flux of light received by a cinematograph screen with the output of the arc in Lumens that the inefficiency of the ordinary projecting lantern could be demonstrated. Similarly, in view of the different degrees of dispersion met with in forms of searchlights, using respectively arcs, oxy-acetylene, or electric incandescent coiled filaments, such apparatus should not be rated in max. candlepower alone. This was undoubtedly a very important, —perhaps the most important—factor. But the light yielded at angles slightly outside the angle of max. c.p. was also of importance. The beam from a searchlight being circular in section the flux of light could readily be obtained experimentally by dividing the section of the beam into concentric annuli, multiplying the area of each successive portion by the corresponding illumination thereon, and adding up the products.

Mr. L. GASTER said the thanks of the Society were due to Professor Morris for having undertaken to open the discussion at somewhat short notice, and to Mr. Willcox for the very useful explanatory matter which he had provided in his contribution.

The question of the best method of specifying the illuminating value of lamps had been raised at several meetings of the Society. Since then the proposition that lamps should be rated in Lumens had been officially endorsed at the Convention of the American Illuminating Engineering Society, in which both the electric and gas interests are strongly represented. This decision made it necessary to re-open the subject, and the whole matter was one of great future importance in relation to the international consideration of methods of rating lamps. As such it would no doubt receive the attention of the National Illumination Commission in due course.

It appeared that the leading lamp makers and manufacturers of shades and reflectors in this country were favourably considering the proposal. There had been unquestionably a great deal of looseness in the methods of stating candlepower of lamps hitherto adopted, and if the new method would bring about greater uniformity and accuracy it would be welcome. Naturally, as Mr. Willcox had said, a good deal of educational work would be necessary to make the term familiar, and the Illuminating Engineering Society would gladly co-operate with lamp makers in producing a pamphlet explaining the use of the Lumen for rating lamps, and its value in illuminating engineering calculations. Such a pamphlet was very necessary in the interests of the general public, and if rating in Lumens became general it would provide a proper basis on which they could judge the importance of each new improvement in illuminants as it occurred.

The CHAIRMAN, in summing up the discussion, said that he had taken part in a great controversy about the Lumen and its relation to candlepower in May, 1914,* and he had been regarded as an old-fashioned conservative heretic. But that discussion was of a philosophical nature and his main contention resembled the theorem of the egg and the hen—which came first?

He had clearly stated that he neither disparaged the Lumen as a theoretical quantity† nor under-rated it as a practical unit. Prof. A. Blondel has, in the Lumen, given invaluable assistance to those engineers who have to make calculations. Two or three definitions of the Lumen had been proposed during the discussion, but he had not seen one which made him happy. He wanted a definition for the man in the street. If such a man were told that the 16 horizontal candlepower is going to be called 158 Lumens, he will think there is a catch and that he is going to be "had."

The lamp trade had settled that they were going to rate their lamps in Lumens. They were all entirely in the hands of the lamp trade as those who have to use continuous current at the higher voltages know to their cost. Still he would like to find a popular definition and a plausible excuse for this rating, not so much to assist the lamp makers as to help those members of the Illuminating Engineering Society who would certainly be called upon to explain what it was all about.

Mr. F. W. WILLCOX, in reply, stated that many of the questions in the discussion were answered in his paper which he regretted through lack of time he could not read in full. He would therefore refer all interested in the discussion to the full paper and diagrams accompanying same, requesting that it be studied in its entirety, when he ventured

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* *Illum. Eng.*, Vol. VII., pp. 339, *et seq.*

† *Loc. cit.* p. 35.

INDEX, January, 1917.

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Illuminating Engineering Society—

(Founded in London, 1909)

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to hope that many of the objections and the queries raised would be satisfactorily answered.

He noted particularly in the case of Mr. Wise's comments that his points of objection arose out of a misunderstanding of the nature of the Lumen. The value of the Lumen is not affected by the unit of distance.

He was particularly interested in the difficulties Mr. Clark referred to in connection with candlepower distribution curves. This whole question was very fully covered in the paper, and Mr. Clark's fears and objections quite fully replied to. Contrary to the views expressed by Mr Clark, the Lumen values, once established, would ensure more than ever the provision of complete data for all forms of light distribution. Results would be much more convenient and intelligible when the lighting values for various sections (zones) of the distribution curve are expressed in Lumens which can be added together or subtracted to give the total Lumens in any way desired. The Lumen would therefore provide a definite means of comparing the total amount of light given by different lamps with different reflectors, and would simplify and help to evaluate the candlepower distribution curves in a way that was not possible with candlepower values.

He sincerely hoped that representatives of gas would find it possible to fall in with the idea of the Lumen. Surely such a unit by reason of its obvious advantages would be a desirable one for all forms of lamps and every branch of the lighting industry, gas as well as electric.

As regards the suggestion of Mr. Stroud for the adoption of a Lumen value 10 times greater, to be known as the large Lumen or "Deka-lumen," this suggestion seems a desirable one on first thought, but further consideration shows it is not so. The larger numerical value the Lumen value provides is valuable, in that it permits a more accurate expression of efficiencies than would be possible with a smaller unit such as the candle power. It is well known that the common expression for efficiency for electric lamps "watts per candle" is really the inverse of the proper efficiency expression, which should be "candles per watt." The watts per candle expression, however, was adopted simply because the candles per watt was, for electric lamps, always a fraction, whereas watts per candle gave a whole number and was thus preferred. By retaining, therefore, the full numerical quantity of the straight Lumen, we have a full numbered (instead of a fractional) value, which permits accurate expression for efficiencies in the term "Lumens per watt."

As an example of this, let us take the 30 watt 200 volt vacuum type tungsten filament lamp, whose total Lumens is 229, giving an efficiency of 7·63 Lumens per watt. If the large Lumen idea was adopted, this would result in our having 22·9 large Lumen for the Lumen value and the Lumens per watt would be a fraction, namely, 0·763.

As to the simple definition of the Lumen which Mr. Trotter desires, I have endeavoured in my paper to give this, and at the same time to enlarge the idea of the Lumen by a somewhat lengthened description, so as to present the conception in various ways. It would be wrong to infer because some place is thus given to the definition of the Lumen that there is any question as to the Lumen being a term of precise meaning and having an exact value. It will naturally depend upon the unit of candlepower adopted, but as the international unit of candlepower is now generally (with the exception of Germany) adopted, this fixes the value of the Lumen absolutely.

In the opinion of the speaker, the simplest definition of the Lumen is to state that it is the amount of light that gives an illumination of 1 foot candle on 1 square foot of area. This is the definition that has been employed in lamp publications recently issued by the writer.

Professor J. T. MORRIS, in reply, said that he regarded the suggestion that the Society should issue a pamphlet as a most valuable one. In the first place it would clear the minds of those who wrote the pamphlet, and then it would be very helpful to those who had to handle practical illumination problems. The suggestion had also been made that lamps might be most useful to scientific people as well as to those who wanted to know the real efficiency of the lamp, and it was a suggestion he would support very strongly.

Communicated: -Dr. Rabinovitch's suggestion to use the Fleming factor, *i.e.*, the factor by which to multiply the horizontal candlepower in order to obtain the M.S.C.P. is quite sound so long as no spiralised filaments are used; but now that half watt lamps have come to stay, and others with similar arrangements of filaments, sometimes permanently combined with reflectors, it is practically useless.

I cordially support Mr. Clark's suggestion that more time might be devoted at some at least of our educational institutions to practical problems in connection with illumination.

Summing up, it appears that one speaker is rather against the practical use of the Lumen, three are more or less open to conviction, and the remainder, eight in number, are definitely in favour of its use in practical work.

In particular Mr. Willcox, Mr. Dow and Mr. Stroud make out good cases in support of the change. Under the circumstances I consider that a clear case has been made out for the Illuminating Engineering Society to take the necessary steps to assist in the proposed reform.

[We are holding over to our next number special contributions from Mr. A. P. Trotter and others dealing with the definition and use of the Lumen.—ED.]

OBITUARY.

We learn with regret of the death of two valued Corresponding Members of the Society, Prof. S. A. Rumi, of Genoa, and Prof. Dr. Friedrich Erismann, of Zurich. Prof. Rumi was keenly interested in photometric problems, and Prof. Erismann a well-known authority on natural school lighting. A fuller note on this subject will appear in due course.

ELECTRICITY · ACETYLENE · OIL · GAS

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Edited by
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EDITORIAL.

The Effect of Contrast on Vision.

The discussion opened by Dr. Kerr's paper at the last meeting of the Illuminating Engineering Society, with which we deal in the present number (pp. 39—58) raised a number of interesting points, notably the effect on the eye of extreme contrast in brightness. The question of glare, as Dr. Kerr pointed out, formed the subject of one of the earliest discussions of the Society in 1910, but since then there have been a number of researches which have considerably enlarged our knowledge of the effect of glare on the eye.

One point, emphasised in recent discussions of the American Illuminating Engineering Society, is the importance of *contrast*. It is now accepted that it is not enough merely to define the absolute brightness of luminous objects within the field of view. To aim, for example, at a maximum brightness of 3 candles per square inch (the average brightness of the white sky) may be a useful principle, but it is necessary also to bear in mind the state of the eye, when observing this object, as affected by the brightness of surroundings, or its previous experience. In fact, the degree to which a luminous object may appear glaring depends on the state of adaptation of the eye.

As a tentative step towards the specification of these conditions, Dr. Kerr recalls the suggestion that the ratio of brightness in the field of vision should preferably not exceed 100 : 1. In recent discussions of the Society there have been several illustrations of the effect of great "simultaneous contrast" in which this ratio may be exceeded. For example, in rifle range lighting experience showed that an extreme contrast between the brightly lit target and the relatively dark surroundings is undesirable. Again, in the conditions recently prevailing in the streets (but now happily being modified in accordance with the latest regulations of the Authorities), the sudden transitions from bright patches of light under the lamps to complete obscurity in the more remote parts of the street were generally recognised to be highly inconvenient and distracting to drivers and pedestrians.

Such extreme contrasts may be prejudicial when both the bright area and the dark area are simultaneously visible, as, for example, in the case of rifle range lighting mentioned above, or in the case of strong local lighting in an office or factory with relatively little general illumination. But they are equally objectionable when the change is brought about successively by a person passing from a dark area to a very brightly illuminated one, or vice versa. The distraction caused by such changes might quite possibly lead to accidents, the eye, in its unadapted state failing to perceive steps, moving vehicles, etc.

It is therefore desirable that in public buildings the contrast between the lighting in halls and vestibules should not be excessive. There should be a gradual transition from the interior to the exterior conditions.

Readers must be referred to Dr. Kerr's Paper for the analysis of the construction and functions of the eye, and their relation to its experiences of glare. It is evident that there is room for a great deal of research in establishing the conditions of contrast most favourable to vision. The suggested ratio of 100 : 1 for the maximum contrast desirable appears to rest mainly on practical experience ; it would be extremely useful if a series of researches could be carried out in the laboratory to corroborate this suggested ratio. Some experiments in this direction have been made in the United States, but the work might well be confirmed and extended in this country. Another matter deserving of study is the degree of flicker which is appreciable to the eye, with a view to specifying the desirable "steadiness" of a source of light. Yet another question is the relation of these factors to the conditions in cinema theatres, to which special reference was made in Dr. Kerr's Paper.

Conditions of Illumination in Cinema Theatres.

The discussion on this subject at the last meeting of the Society was timely in view of the investigation now being conducted by the Cinema Commission, two members of which, Dr. C. W. Kimmins (Chief Inspector of Schools to the London County Council), and Mr. A. E. Newbould (Cinematograph Exhibitors Association), were present, and officially invited the Society to form a small committee to co-operate with the Commission in examining the lighting conditions in cinema theatres, and to report upon any improvements, to be observed, if possible, throughout the country.

This proposal was welcomed by Mr. Goodenough, the Chairman of Council of the Society and supported by the Hon. Secretary.

Conditions in cinema theatres afford an interesting instance of the need for co-operation between different experts. Seeing that such displays cater entirely for the eye the peculiarities of this organ require careful study by oculists and physiologists. On the other hand, the conditions of lighting which give rise to healthy or harmful effects require investigation by lighting experts. Nor must it be forgotten, as the President remarked, that the eye is an "off-shoot" of the brain, so that harmful impressions received by the eye may react on the brain and lead to injury in other directions.

Films depicting incidents of an exciting and vivid character may be unsuitable for young children, and in any case should not form intervals in an educational programme which require calm and continuous mental effort.

Even for adults the above considerations are of importance In the case of children, whose eyes, brain, and physical conditions generally are in a state of development, and therefore easily harmed, the matter is of special importance, especially in view of the educational possibilities of the cinematograph and its potential wider use in schools.

That the conditions of vision in a cinema hall are abnormal in several respects, is evident. The eye is gazing constantly in a fixed direction at a highly luminous screen, with relatively dark surroundings and extreme contrast. The projection of pictures, even in the best conditions, is attended with a certain degree of flicker and fluctuations in light, which may be accentuated by imperfections in the film, lantern, or screen, or a combination of such defects or by unsatisfactory conditions of illumination. In any case there is a certain strain on the minds of children in receiving the rapidly following impressions, and it has therefore been suggested that the duration of entertainments for young people should be limited and that special measures, in the form of preliminary explanations, should be taken to make the subject of the film readily understood. Among other matters calling for investigation are the desirable distance of observers from the screen, the provision of a moderate general illumination in the auditorium designed to lessen contrast and yet not impair the image on the screen, and the graduation of illumination in vestibules and corridors with a view to lessening the sudden transitions in brightness and darkness in passing from the hall to the street outside. Needless to say any bright unscreened lights liable to cause distraction and glare in the auditorium should be avoided, and measures should preferably be taken, by the use of dimmers, etc., to reduce or increase the illumination gradually when a film is ended or commenced.

All these are matters which would well repay investigation and no doubt the Committee of the Illuminating Engineering Society will be able to make suggestions which will be of genuine public benefit.

Street Lighting and Accidents.

When the diminution in street lighting was first undertaken, shortly after the outbreak of war, we foresaw that unless this darkening was carried out on scientific lines, it might lead to inconvenience to traffic and an increase in accidents. At the first meeting of the Illuminating Engineering Society held on Dec. 1st, 1914, attention was drawn to the objectionable contrasts in light and shade resulting from the methods of screening employed, and it was suggested that attempts should be made to secure more even distribution of light. Shortly afterwards, in an editorial on the same subject, it was remarked that an increase in street accidents, partly attributable to the lighting conditions was already becoming apparent.

The results of two years experience were summarised in the discussion before the Illuminating Engineering Society on December 15th last year. Statistics were quoted, indicating a progressive increase in street accidents since the outbreak of war, but it was pointed out that fuller details were needed in order that the effect of the diminished lighting might be clearly traced. In particular, it was desired that the accidents should be given for each month, and a division made between those occurring respectively by day and by night.

Some interesting figures have since been given for the metropolitan area, a classification by day and night now being made, although only the total casualties in each year were stated, and not the number each month.

These figures are as follows :—

Year.	Killed.				Injured.			
	Day.	Night.	**Percentage increase from 1913 to 1915.**		Day.	Night.	**Percentage increase from 1913 to 1915.**	
			Day.	Night.			Day.	Night.
1912	461	77			17122	3044		
1913	518	90	**34%**	**73%**	20380	3385	**6%**	**21%**
1914	523	116			21554	3916		
1915	695	156			21755	4112		

An examination of these figures shows that while there has been apparently a tendencey for all accidents to increase, the rise has been proportionately much greater by night than by day. They therefore afford evidence that the diminished lighting, which began in 1914, but was carried on continuously throughout 1915, was an influential factor. Possibly, if the figures of 1916, and particularly the dark winter months, were available, the results might be yet more striking. For example, Dr. Ingleby Oddie, the Lambeth Coroner, recently stated that the number of fatal accidents coming under his notice had increased from 17 in October, November, and December, 1913, to 47 during the corresponding period of 1916.

The question of street lighting in relation to accidents is now receiving attention from a sub-committee of the London Safety First Council, on which the Illuminating Engineering Society is represented. It is satisfactory to know that a record is being kept of changes in lighting and their effects, and after the cessation of hostilities the experience now being gained will no doubt provide a very valuable subject for discussion at the hands of the Illuminating Engineering Society.

LEON GASTER.

TRANSACTIONS

OF

The Illuminating Engineering Society.

(Founded in London, 1909.)

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

THE EFFECT ON THE EYE OF VARYING DEGREES OF BRIGHTNESS AND CONTRAST.

(Proceedings at a meeting of the Society held at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, W., at 5 p.m., on Tuesday, February 20th, 1917.)

A MEETING of the Society took place as stated above, on Tuesday, February 20th, at 5 p.m., the chair being taken by the Prosident (Sir William Bennett, K.C.V.O.).

The minutes of the last meeting having been taken as read, the HON. SECRETARY read out the names of the following applicants for membership :—

Ordinary Members :—

Campbell, J. B.	Assistant Electrical Engineer, Public Works Department, Sydney, NEW SOUTH WALES.
Luckhurst, T. W.	Secretary, Weston-super-Mare Gas Light Co. (Bracewell, Milton Road, WESTON-SUPER-MARE.)

Corresponding Member :—

Hammer, W. J.	Consulting Electrical Engineer, 55, Liberty Street, NEW YORK CITY, U.S.A.

Honorary Member :—

Blondel, Prof. A.	41, Avenue de la Bourdonnais, PARIS. *(In recognition of distinguished services to the study of illuminating engineering in France.)*

The HON. SECRETARY, referring to the nomination of Prof. A. BLONDEL as one of the Honorary Members for the current year, said that Prof. Blondel's services to illuminating engineering in France were known and valued by all who were engaged in the study of this subject. He had been one of the very earliest pioneering workers in this field, and his name was associated with many important scientific investigations. Prof. BLONDEL had taken a deep interest in the work of the Society, and this was an opportune moment to express its appreciation of his distinguished services.

Mr. HAMMER, who had been nominated a Corresponding Member, was one of

Mr. Edison's original assistants, and had been closely associated with the early development of the electric incandescent lamp, as well as with scientific work on phosphorescence and fluorescence.

The HON. SECRETARY also read out again the names of those applicants for membership nominated at the last meeting of the Society,* and these gentlemen were formally declared members.

The PRESIDENT then called upon Dr. JAMES KERR to read his paper on "The Effect on the Eye of Varying Degrees of Brightness and Contrast" (see pp. 41-49).

In opening the discussion on the subject the PRESIDENT remarked that many of the points dealt with by Dr. KERR were of very great importance in relation to lighting problems, and he had dealt in a very lucid and interesting manner with the many curious phenomena characteristic of the eye when adapted to strong and weak illuminations. The section of the paper dealing with conditions in cinematograph theatres was of special importance. He thought there was some danger that those who were concerned with the moral influence of such exhibitions on children might overlook the possibility of physical injury. The eye was a highly sensitive organism, and when in process of development was particularly susceptible to overstrain. It was therefore most important that the conditions prejudicial to the eyesight of children should be studied and precautions taken against any possible sources of injury.

An interesting discussion then took place in which the following took part:

Mr. J. W. BARBER, Mr. J. G. CLARK, Mrs. CLOUDESLEY BRERETON, Mr. A. CUNNINGTON, Mr. J. S. DOW, Dr. F. W. EDRIDGE GREEN, Mr. L. GASTER, Mr. F. W. GOODENOUGH, Dr. C. W. KIMMINS, Lieut. S. R. MULLARD, R.N.V.R., Mr. A. R. NEWBOULD, Mr. E. T. SWINSON, and Mr. A. P. TROTTER.

The ASSISTANT HON. SECRETARY also read a number of letters from various members of the Cinema Commission, regretting their inability to be present, but expressing interest in the discussion, and written contributions from Dr. ERNEST CLARK, Mr. N. BISHOP HARMAN, Mr. COLIN BENNETT, and Mr. E. G. KENNARD, were read.

Dr. C. W. KIMMINS (H.M. Chief Inspector of Schools) and Mr. A. E. NEWBOULD (Chairman, Cinematograph Exhibitors' Association), speaking on behalf of the Cinema Commission, expressed their interest in the problems raised in the paper and conveyed to Dr. Kerr an invitation to give evidence before the Commission. The hope was also expressed that the Society would nominate a small committee to co-operate with the Commission in determining the best conditions of illumination and other factors of importance in relation to eyestrain.

Mr. F. W. GOODENOUGH (Chairman of Council) expressed the appreciation of the Society of this invitation which would be brought before the Council at their next meeting. The Society would be only too glad to be of assistance in this matter.

At the conclusion of the discussion a vote of thanks was given to Dr. KERR for his paper. The PRESIDENT announced that the next meeting would take place at **5 p.m.** on **Thursday, March 22nd,** when a discussion on "**Phosphorescence and Fluorescence,** and their use to produce Luminous Effects," would be opened by **Mr. F. Harrison Glew.**

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* *Illuminating Engineer*, January, 1917, p. 5.

EFFECT OF CONTRAST IN VISION.

The most recently received number of the Transactions of the Illuminating Engineering Society, U.S.A. (No. 9, Vol. XI., Dec. 30th, 1916), contains several items: "Effects of Brightness and Contrast in Vision," by P. G. Nutting; "Apparent Brightness: its Conditions and Properties," by L. T. Troland; "The Effect of Brightness of Light Sources on General Illumination," by F. C. Caldwell, which deserve study in connection with the points raised in Dr. Kerr's paper.

THE EFFECT ON THE EYE OF VARYING DEGREES OF BRIGHTNESS AND CONTRAST.

By Dr. James Kerr (Public Health Department. London County Council).

(Paper presented at a meeting of the Society, held in the House of the Royal Society of Arts, 18, John Street, Adelphi, London. W., at 5 p.m., on Tuesday, February 20th, 1917.)

I wish to-night to take a very simple glance at illumination from the point of view of the work called for from the eye, and therefore will confine myself to indicating a few topics of interest which seem to deserve discussion.

Almost the first of the Society's proceedings in its initial session in 1909 - 1910 was to send out a set of questions dealing with the subject of glare. It was difficult to assign any kind of definite answer to many of these questions, but since then we have travelled far.

The discussion which ensued opened up a variety of topics and was followed by other discussions or Reports of Committees. Whilst in some cases rules have been formulated and regulations suggested, others are waiting a satisfactory solution either because this would require time and money expended in actual laboratory researches which we have not at present the opportunity of carrying out or else because there is wanted time for the filtering of knowledge, and permeation beyond technical circles to bring about legislative changes and regulations.

The subject of glare put in the forefront of the Society's activities has enormous practical bearings, and the corresponding Society in America is doing much work to co-ordinate theoretical knowledge with practical usefulness.

One may not hit a man on the comparatively insensitive skin without running the risk of legal or other penalties, but may with impunity, literally hit him in the eyes with a thousand candlepower beam. Short, however of this, the effects of glare are daily felt and far-reaching.

Lighting belongs to the amenities of life, and can be made an artistic pleasure if scientifically used but can be the very reverse by becoming a vulgar intrusion or glaring disturbance.

Individuals differ much in their reactions. A healthy muscular labourer could endure hours of lighting conditions, without remark, which in a sensitive, less well nourished, or possibly chronically fatigued worker might be the cause of lasting distress or ill-health.

Before proceeding to some practical examples of such effects, I propose to sum up the simplest physiological aspects of vision which should be kept in mind if the art of illumination is to be made a pleasure instead of an infliction.

While much of this information may appear elementary to those acquainted with opthalmology, it seems desirable, for the benefit of those concerned rather with the practical aspects of light, to make a few remarks on this subject.

Fundamental Properties of the Eye.

The psychology of the subject has to be remembered. The intellect builds up conceptions from past memories, and the merest hints of present things, and is easily deceived by ocular tricks, not only form, space, colour and distance, but of meaning and interpretation.

These physical judgments too are remarkably at fault in unaided estimates of quantity or quality of lighting.

It had been known for a couple of generations that the eye had great power of adjustment in relation to light. A power called *adaptation*.

The Importance of "Adaptation" in the Eye.

Adaptation has scarcely been sufficiently allowed for in practice, and was not put forward clearly as the essential factor in differences of lighting as for instance natural and artificial, till the discussion on glare took place.

At that time I had the idea that the range of adaptation, measured by the sensitiveness the eye attained in the dark was twenty or thirty times its sensitiveness in daylight. This estimate has been continually raised by almost every worker in the last half dozen years, and in the Report* published by a Committee of the American Society during the past year they state "Visual sensibility is fully a million times as great after half an hour rest in darkness, as in broad daylight."

This adaptation of the eye for light depends on a mechanism in the retina. The retina in which the image of the visual field is formed consists of a sheet of nervous tissue, really an outgrowth of the brain. The light penetrates this to about the depth of a fifth of a millimetre to reach the sensitive layer of rods and cones, which layer is itself backed by the layer of black pigment cells. This last layer not only prevents irregular dispersion and reflection but also acts as the chief machinery in the light *adaptation* of the eye.

In passing it may be remarked that *adaptation* of the retina, is quite distinct from *accommodation* of the eye by the lens as these terms are used in ophthalmology. The distinction should be maintained, although accommodation is occasionally used where adaptation is meant.

THE RETINAL STRUCTURE.

To understand this adaptation we must know a little more of the retinal structure. From within where the light first strikes it, there are several layers of nerves and nerve cells, making up about nine-tenths of its thickness; these have to be penetrated by the light, then comes sharply defined the layer of rods and cones. This layer is shown to be the sensitive region because the only spot where it is absent, at the entrance of the optic nerve, is quite blind, the blind spot, big enough to take a penny on a sheet of paper at a foot distance. The rods and cones are somewhat cylindrical bodies, standing endwise on to the light, and roughly consist of an inner more swollen half and an outer thin and transversely striated part, the outer end of which abuts on the pigment layer. From the pigment layer fine prolongations of the pigment containing cells extend up between the rods.

If no light has been falling on the retina for some time, as for instance in an animal kept in the dark, the pigment granules in the cells form a thin layer, dense and black, just touching the outer ends of the rods.

If however the eye has recently been exposed to light so that the retina is adapted thereto, the prolongations or processes of the cells running up between the rods are filled with the black pigment granules. They not only help to absorb light, but are probably actively engaged in renewing a photosensitive material the so-called visual purple, contained in the rods. When the rods are highly charged with this, and light has full access to them, as in the dark adapted eye, they appear exquisitely sensitive to the slightest variation, but when this purple material is largely used up, and the light greatly damped by the migrated pigment granules, the rods are seemingly much less sensitive, a million times less as the recent Report says.

The cones already mentioned are thicker and shorter and very many fewer than the rods. One observer estimated seven million cones and 130 million rods in the adult. Towards the periphery the rods become fewer and the cones disappear.

At one part of the retina, all the layers thin out, and at last disappear except the cones. This is the little central area known as the *macula*, and the centre of that with only big cones, is known as the *fovea*. It is the area of greatest distinctness of vision. This area is perhaps half a millimetre across, and the whole macula one to two millimetres. This part is the real eye which is used for exact knowledge the rest of the retina giving indications or hints to orient the exact sensations at the macula. For this reason the rest of the retina is sensitive to movements of light or shade or to the merest flicker but not to form. Some think that the rods merely distinguish light, whilst the cones analyse form and colour.

It is the macular vision which is so enormously important, and which reacts to fatigue and poisons. With excess of tobacco the reds and greens disappear in the exact spot looked at, so that a pin head dipped in red sealing wax and another in green fail to be distinguished. This may come on with anyone, especially above middle age, who uses more than three ounces of tobacco weekly. It would affect all fine work, or the distinguishing of signals, or skill in sniping.

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* Committee. Ill. Eng. Soc., U.S.A. Report, No. 11, p. 31. "Automobile Headlights." See also Paper by P. G. Nutting, on "Brightness and Contrast in Vision," presented at the Tenth Annual Convention in Philadelphia, September, 1916.

The centring of the eyes on the object looked at is accomplished so automatically that anything looked at should have its image fall on the macula. This is scarcely recognisable till actually tested, but if a certain small spot, say the dot of an "i" in a newspaper held at a foot distance, is carefully fixed by one eye, and *without moving the eye* from this fixation point, the number of letters clearly seen simultaneously is determined; it will be found that the area where vision is good enough to distinguish the forms of a newspaper type at a foot off, can be covered by a shilling.

In any exact vision then the eyes are constantly being centred on little spots like this, and the rest of the retina merely gives rough orientation.

This centring of the eyes means muscular adjustments so that the axes cut through the point looked at and is termed *convergence.*

In reading the eyes go along a line in a series of little jumps fixing a series of such spots in succession though not necessarily in contact, but sufficient to give hints of words, which the brain can use, and if the light is poor, or the image confused, or the text strange, greater exactness of fixation is required, which is the beginning of strain, causing the sense of one variety of glare.

Nothing has been said yet about the action of the iris, which contracts on exposure to light, and also on efforts at accommodation. With rapid variations it may be a cause of strain, and possibly is a main agent in the irritating effects of flicker, but the range of protection gained from adaptation must be thousands of times greater than any momentary effect from the iris. Apart from flickering variation of light any strain or discomfort through pupillary contraction can probably be neglected.

There is, however, another action in addition to the centring of the image on the macula by convergence, and that is the focussing of the image on the layer of rods and cones by the action of the lens. This is called *accommodation*, and is the only sense in which the word should be used, although it is not infrequently used when adaptation of the retina is meant. Accommodation is of considerable importance in the form of glare due to surfaces of low intensity, shiny paper and so on.

The exactly focussed image is as a rule the only one attended to, unless another image obtrudes, when difficulties and a sense of glare may become apparent.

Each object as looked at is focussed as clearly as possible on the retina. Accommodation is probably being varied all the time, as the eye, is not achromatic, and different coloured images overlap. Judgment is very deceptive here. The black posters of the Underground Railways give a good example. All the letters are in the same plane, but the slight excess and different amount of accommodation for focussing a red line makes it appear to be nearer in comparison with a green line, or the black surface.

From this cause one poster with an outlook from a tunnel on green fields and red roofs attains almost stereoscopic relief.

Effect of Chromatic Aberration.

For exact work the nearer the light to monochromatic the clearer the image. Some coloured glasses amber, chlorophyl and so on which cut down the extremes of the spectrum, certainly add clearness in the effort to focus the distance, as deer stalkers and others have found. Here too even in this chromatic accommodation we can find evidences of strain and glare.

I have recently been charting a certain series of records in which interpolation figures were set down in black, at first I did it without lines. One day to make my lists tidier I drew a series of vertical and horizontal columns with red ink, and in half an hour had a violent headache from eye strain. I tried black lines without trouble and also red lines with red figures with less trouble. It was obviously the extra work of focussing the red and black exactly which produced the sense of glare.

There are then these three main ocular mechanisms *Adaptation*, *Convergence*, and

Accommodation to consider in any lighting problems as regards the effect on the eye. These effects where (a) no immediate result is noticed may be grouped as strain, or (b) with immediate discomfort and inability to work, glare.

As I have said the eye usually works in quite an inexact way, just picking up rough hints. Any muscular actions are in the normal eye well within its powers. For instance accommodation is comfortably used to about one third of that possible, more can be used if necessary, but soon gives rise to fatigue and strain.

It is usually taken that with test type the image of two points or two lines at an angular distance of one minute can be discriminated, but Dr. Walter Lancaster* refers in a paper recently to stereoscopic observations which show discrimination of separation as low as 3 to 12 seconds, corresponding to an adjustment of the retinal image in thousandths of a millimetre.

The eye is never at rest, it roams over an object, picking up hints, or runs along a line of print, stopping five or six times to take up the meaning, but never maintaining a steady fixed effort for long. Yet it can establish the effort to thousandths of a millimetre if necessary. If an object is so fixed that in an attempt to get a clear image every possible adjustment is made, the utmost reserves have to be called up for this steadiness. Too poor an image on the retina seems the chief cause. Either the light is absolutely too poor or the contrasts insufficient, from retinal conditions, or from veiling through extraneous light, as from a shiny page.

During the period of growth nutrition is often seriously interfered with, and the part of myopia which is school or work produced is essentially due to these causes. Our own Committee suggested 2 foot-candles on every desk as the minimum requirement, but three would not be an unsatisfactory average for school children.

Chronic conditions of poor light and black surfaces set up the curious functional disturbance which passes into actual disease of the nerve centres from long continued strain, in what is known as miners nystagmus. Men who work in thick seams rarely get it, but when the eyes have to be strained in narrow seams it is common. Long before it is obvious the symptoms can be elicited by turning the eyes to look up and to one side, when the jerking tremor comes on.

THE ABSOLUTE GLARE LIMIT

Turning now to another aspect of glare that from bright sources—with every eclipse of the sun cases are recorded where individuals looking at the partially eclipsed sun without protecting glasses, receive permanent damage. The sensitive layer or the nerve structures about it are burned out functionally at the macula, and a permanent black spot remains on the field of vision. This represents the extreme case of glare from high intrinsic brilliancy.

After any bright object is looked at, the destruction of visual purple, and accompanying changes are so rapid and intense that time is taken up in the restitution of the original condition, and during this time after images occur. They should normally disappear in the fraction of a second, but with intense light, or with poor circulation in the eyeball, or certain depressed conditions of nerve structures, which may be quite temporary as from a bilious attack or more lasting from neurasthenia, these after images may persist to such an extent that glaring effects result. In this connection fatigue and excess of tobacco are always to be thought of.

Mere glare effects from continued images of the source of light in the field of vision may be quite exhausting. The Hall at the University of London where some educational conferences were held last month is a particular example of an extremely offensive lighting.

Apparently the maximum brightness which the eye is prepared for through its long course of evolution is the brightest sky, apart from the actual image of the sun. That nature has prepared us for this may be judged from the pigmentation of the eyes of southern as compared with their slighter coloration in northern races. This amount is generally taken as 2.5 to 3 candles to the square inch, and some such amount has been suggested as the standard for any visible sources of lighting.

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* "Eye Strain, etc." Dr. W. B. Lancaster. New York Med. Journ., August 29th, 1914.

INDIRECT AND SEMI-INDIRECT LIGHTING.

Indirect lighting may accomplish this to perfection, but the semi-indirect can also be utilised if the actual incandescent source is used as a primary to light a sufficiently large diffusing shade which will act as a secondary source, which can be looked at steadily without hurt to the eye. Indirect lighting has its restfulness due to its diffuseness and absence of high intrinsic brilliancy on any surface. The eye is saved much fatigue by absence of violent contrasts, and by not having to pass from a comparatively dark surface to an incandescent one quite suddenly. On the other hand as it is only through shadows that objects are seen, comparatively shadowless lighting, whilst useful for general illumination apart from special eye work, or for examination of plain surfaces reading or writing, is not so useful where small objects or textural surfaces have to be examined. It would thus be good in a bank but bad in a school.

Direct lighting is the most economical method for handling objects or manufacturing processes, but there again if the light source is not kept out of the field of vision, or shaded down to the 3 c.p. per inch standard for any visible surface, it will cause strain and fatigue.

THE EFFECT OF CONTRAST.

The matter of contrast which comes in here, is of very great importance not only in regard to light sources which may be the cause of after images, and distribution of light, but also for such problems as the kinema screen. Excessive or defective contrast may be equally troublesome. The New York Committee * who investigated glare a couple of years ago stated that vision was best with contrasts about 1 : 20, but was possible at 98 : 100, and could be done without discomfort up to 1 : 100. In sunlit scenes out of doors, excluding the sun itself, the contrasts rarely exceed 1 : 20. Indoors not over 1 : 200, although window frames against a bright sky may give a contrast 1 : 10,000. They thought it probable that the comfortable limiting ratio lies between 1 : 100 and 1 : 200 and preferably should be kept below 1 : 100.

This appears to me an important suggestion. It seems to take into account the admitted fact that a bright object is more distressing to the eye when presented with a dark background, than if seen amidst relatively bright surroundings owing to the adaptation of the eye ; in full daylight with an eye adapted to relatively great brightness, even an incandescent filament may not appear very glaring, whereas in the dark a lighted match, held near the eyes, produces temporary dazzle.

The factor 1 : 100 appears to have been suggested mainly by practical experience. It was suggested in Prof. L. Weber's contribution to the discussion on glare in 1910 and now receives a measure of official support by being put forward by the Committee of the American Illuminating Engineering Society. It would, however, be more satisfactory if detailed physiological evidence in support of the ratio could be obtained in the laboratory and this appears to be a matter on which the Society might well initiate investigations.

PRACTICAL ILLUSTRATIONS OF EFFECT OF CONTRAST.

Even in cases where the surfaces are of moderate brightness and no extreme form of glare would be imagined to exist an extreme contrast, or a contrast operating in the wrong direction, may be inconvenient. An instance in point appears to be furnished by the discussion on the Lighting of Rifle Ranges before the Society in 1915. The view was generally expressed that to many people a brightly lighted white target with a dead black background gave an acuteness of vision inferior to that obtained when the surroundings were illuminated with subdued illumination. This appears to be a case where a fixed ratio of brightness between illuminated object and surroundings would be desirable. Similar effects are met with in stage lighting, and in the cinematograph theatre, to which reference will be made shortly. It seems questionable whether the practice of keeping the auditorium of a theatre in complete darkness is desirable. In some cases the continued fixation of a brightly lighted spot on the stage, with the rest of the field of

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* I.E.S. Amer. Report, No. 12, "On Glare," 1914–15, p. 37.

view in complete darkness, entails a strain on the eye.

The fixing of a desirable limit to contrast has also a bearing on local illumination. It is hardly possible to lay down the law that either "local" or "general" lighting is invariably best; but the extreme contrast present when a workman is engaged on fine work, and using a powerful shaded light operating over a small area, with the surroundings in complete darkness is undoubtedly trying. Here again a limit to the contrast might well be prescribed.

This raises one other question. Should there be also a limit to uniformity? The view is often expressed that completely uniform lighting, (were it attainable), would also be trying to the eyes. Is extreme monotony of brightness also objectionable? This is a matter on which very little physiological evidence is available but there seems ground for the belief that the best conditions involve an illumination on the object viewed greater than that given to the surroundings. The Committe of the Society on school lighting recommended an illumination of the blackboard in excess of that provided generally in the room. It is, at all events, generally agreed that when the contrast is *reversed, i.e.* when the illumination on the work or object viewed is actually less than the general illumination the visual effect is prejudiced.

ILLUMINATION OF TEST-TYPE.

These problems have also a relation to the illumination of the test-type used by oculists for the examination of eye sight. In cases where the examination is of a rough character the requirements may be met by stating that the card should be "well illuminated," and the contrast between card and surroundings will not be severe in an ordinary room. But for accurate work, and particularly where records are made over long intervals of time, it might be useful to have a standard method of lighting complying with the following conditions.

(1) Uniform illumination on the test card of known value, not less than 3 foot-candles.

(2) No naked sources of light visible in the room.

(3) Minimum contrast of 100 : 1 between card and surroundings.

(4) Progressive measured variation in illumination of card, and of contrast between black letters and background, from high to low values.

(5) Facilities for repeating tests by white, red and green-blue light.

Requirement (4) would be particularly useful in detecting and recording for comparison cases of "night-blindness" in which the degree of contrast perceptible is much reduced at low illuminations. A closer study by oculists of methods of graduating and measuring conditions of illumination under which tests are carried out might have a material effect on precision of testing defects of vision, and it would be helpful if a compact standard form of apparatus complying with the above requirement could be designed.

ILLUMINATION FOR DISTANT OBJECTS.

It may be added in passing that while the illumination needed for close work is fairly well understood, the conditions for relatively distant vision have been less studied. For example there is general agreement that for reading good type on white paper 2—3 foot-candles is the minimum desirable. But the corresponding illumination required for lighting targets, blackboards and illuminated signs and notices to be viewed from a distance has been little studied. Assuming that the angle subtended by the detail at the eye, and the contrast between this detail and the background are the same, would the illumination necessary be different according as the object is viewed at a distance of say 1, 5 and 20 and 100 feet? Probably it would be considerably greater.

Again if we assume that 2—3 foot-candles is needed for close observation of good type on a white background how far will higher illumination enable us to perceive fine detail which cannot be clearly seen at the above illumination? And to what extent will a higher illumination aid us in perceiving detail if the contrast is less than that presented by black letters on a white ground? An investigation, on practical lines into these matters would yield results and might have an important bearing on the question of the amount of illumination necessary for different classes of work in factories.

Glare from "Successive Contrast" and Flicker.

The effects of glare discussed above are due to simultaneous contrast. A corresponding effect occurs when the eye sees surfaces of vastly differing brightness in succession. For example when we pass from a brightly lighted room into the darkness outside, the eye being adapted to the brilliancy inside, can see little until it has become adjusted to the lower brightness. The present darkening of London offers many examples of this effect. The alternate patches of brightness under lamps and darkness between them are doubtless distracting to drivers and pedestrians whose eyes are required to adjust themselves to the altered conditions as they pass from one region to another. This is an argument in favour of more uniform illumination.

An extreme instance of such an effect is met with in the case of a flickering, unsteady illumination which is notoriously trying to the eyes. Flicker is rather a mysterious subject, which would require separate treatment. It seems more evident to the peripheral retina than on the macula, and is due to alterations in light and shade slow enough to evoke continual efforts at adjustment. It is in this respect perhaps that the pupillary contractions of the iris are most to be regarded. This effect might also receive the attention of the Society though it is obviously more difficult to specify as it includes both time and brightness. It should not, however, be impossible to specify the steadiness of sources of light and to state approximately the amount of flicker which is distinctly perceptible to the eye and therefore objectionable. Such fluctuations may occur either on a fluctuating gas supply or an electric lamp run off an alternating supply of low frequency. With alternating current the point at which no flicker is perceptible depends on the damping effect of the filament and the duration of an impression on the retina. This is attained in about 1/20th of a second in average light and 1/5th of a second in very bright light. If the frequency exceeds 50, as is generally the case there should be in general no perceptible variation in the case of stationary objects. As mentioned above the brightness of the light is a material factor. Therefore it is conceivable that an effect which is inappreciable if one looks straight at the filament might be detected if one is observing an illuminated object of much lower brightness.

As is well known inconvenient effects may be produced by moving objects illuminated by alternating arcs. At a certain period of revolution rotating machinery may even appear stationary, an obviously dangerous effect. This method of lighting should not be employed for the illumination of moving objects. The corresponding effect of electric incandescent lamps on alternating supply is very much less, but might in some circumstances be appreciable.

In some circumstances peculiar stroboscopic effects may occur even when the source of light is steady. In a cinema picture, for example, one may notice a rapidly travelling motor car whose wheels are either at rest or moving backward. This is due to the time interval of rotation between two spokes being a multiple of or slightly less than the interval between two pictures. Possibly it would be cured by putting a prominent patch of whitewash on one spoke.

Conditions in Cinematograph theatres.

Flicker at once calls up the much debated question of cinematograph displays. In itself this is a harmless form of amusement, and for educational purposes has undoubtedly great possibilities. In the case of grown up people, whose attendance is entirely a matter of choice any possible prejudicial effect is of less consequence than in the case of children, whose eyes and minds and physique are in the process of development. If cinema displays should become a regular feature in schools, and attendance obligatory, it is evident that all possible care should be taken to avoid any possible injury, while, even in the case of ordinary entertainments there is perhaps a danger that too frequent indulgence in the pastime might have bad results.

The question of the effect of such entertainments on the mind hardly falls within our province. We are, however, concerned with the effect on the eyes, and particularly the conditions that should be observed in the lighting of screen and auditorium generally.

In the first place it should be observed that the constant fixed direction of the eyes in a dark adapted condition is unusual. With the eyes steadily fixed one looks at a distant landscape without trouble, but fixing on a relatively near object may soon give rise to strain. One can test this very easily by watching an electrically controlled clock outside a building for the half minute jerk forward; the effect on the eyes soon becomes appreciable. The question of the length of such entertainments for children therefore deserves attention, and the practice, which I believe, at one time was prevalent, of remaining in the hall and seeing the same series of films over and over again should not be allowed. Even for grown up people the duration of such entertainments is often too long. If the majority of the spectators have normal vision they should see clearly at any distance over 20 feet without effort. Any shorter distance of the screen means effort of both accommodation and convergence and in the case of children owing to their short undeveloped eyeballs that effort is much greater than in adults.

Where there is any indistinctness of the picture the spectator may make efforts to see more clearly, and if less than 20 feet from the screen these efforts are useless, as all images, whether apparently near or far, are on the screen in the one plane.

The best position visually would be from 30 to 50 feet from the screen and on a level with its centre. Raising of the eyes above the horizontal should be eliminated so far as is possible. The strain on the superior rectus muscle which raises the eyeballs very easily causes headaches, as in the notorious academy headache. The screen therefore should be as low as possible.

Where the screen is much foreshortened as when seen from the sides of the hall in front, the efforts to correct the distorted image are very fatiguing and children should be excluded from such seats.

The question of controlling the perfection of the film and the skill of operators is doubtless a difficult one. Certainly the freedom from flicker varies considerable in different classes of halls. I believe that in the cinematograph industry, as in others, there is a progressive circulation of materials from the highest class halls to the lowest. The worst film I ever encountered was one that had migrated to Iceland.

On the question of lighting there is room for experiment but we are in a position to make more definite suggestions :—

(1). *Illumination of the Screen.*

The illumination of the screen will be found to vary from 0·5 ft. candles to 1 foot-candle or more. It has been suggested that the standard value should be fixed at a minimum of 1 foot-candle. The illumination of screens is easily tested and it should not be difficult to arrive at a reasonable value by observations in typical halls.

(2) *Material for the Screen.*

This is essentially a matter for experts. I believe it is generally agreed that a good matt-white screen gives the best effects. Screens composed of aluminium powder have been introduced on account of the greater brilliancy attainable, and consequent economy in the consumption of light. Such screens, it is said, are apt to give rise to inequalityof brightness according to the direction from which they are viewed, and to inconvenient moving shadows. As they are still in the experimental stage it would perhaps be better not to adopt them for entertainments for children.

(3) *Illumination in the Theatre.*

Extreme contrast between the brightness of the screen and of the general surroundings is objectionable. The ratio of 1 : 100 already suggested would imply brightness of surroundings of, say, not less than 0·01.—0·02 ft. candles. In practice this value can easily be attained. A certain amount of illumination on the seats has also been considered desirable to enable people to find their places. A value of 0·2 to 0·5 ft-candles has been suggested for this purpose. By careful design it could be probably be arranged that the provision of this extra illumination would not materially affect the brightness of the screen and would therefore not impair the image.

Any lights or illuminated notices indicating exits, etc., should be carefully screened so that their brightness does not exceed 3 c.p. per square inch. This is ample for the purpose in view but not high enough to cause glare.

The illumination in the theatre should be controlled by dimmers so that it can be gradually diminished before films are shown, thus avoiding the painful effect on the eyes of suddenly switching on and off the full illumination.

The illumination in corridors should have a value intermediate between that outside and in the theatre. An illumination on the floor of 0·5 ft. candles would be sufficient. Here again all lights should be shaded. The convention employed in the early Tube days namely that going towards green lights leads to safety or exits, and that departing from red lights indicates the same precedure, might be adopted.

In this paper I have tried to bring before you a number of aspects of lighting, where the effect of light on the eye requires further study. On many of them more detailed information is required and it is to be hoped that the discussion will be instrumental in stimulating inquiry into them.

DISCUSSION.

The PRESIDENT (Sir Wm. Bennett), in opening the discussion, said that they had all been much interested in Dr. Kerr's paper, and appreciated the very lucid manner in which he had explained certain anatomical and phsiological details connected with the eye—the strange behaviour, for example, of the retinal rods and cones, and of other weird things concerned in the working of this wonderful machine—a knowledge of which was essential for the better understanding of his communication.

The importance of proper methods of lighting generally is receiving more attention in these days, which was largely due to the work of the Society. Probably the most important of all the questions affecting proper lighting were those of glare, flicker and contrast, about which something further would no doubt be said in the ensuing discussion.

From the popular standpoint, the part of Dr. Kerr's paper dealing directly with kinema displays would doubtless attract most attention. Since the introduction of this form of entertainment there had no doubt been an increase in eye-trouble, headache, and brain-worry amongst children frequenting such entertainments. It was not an uncommon thing to hear that a child "likes the picture shows, but they often give him a headache." He also understood that vomiting sometimes followed a visit of young children to the pictures.

Many people were greatly concerned about the tendency to moral harm in childhood of these entertainments, whilst the liability to physical harm was apt to be overlooked—or at all events not to be estimated at its true value. At the present time it was seriously suggested that an age limit should be placed upon children in this connection—a suggestion which should receive support from everyone interested in sight welfare. The eye, which, after all, is for practical purposes an off-shoot of the brain, is, like all other organs, vulnerable and easily deranged during the period of development. The earlier the stage of development the more vulnerable it is—hence the great importance of Dr. Kerr's remarks concerning the effect of kinema glare and flicker upon the eye and brain of young children; this tended not only to impairment of eyesight but to brain worry and instability, and so might contribute to the liability to moral harm.

The HON. ASSISTANT SECRETARY (Mr. J. S. Dow) then referred to a number of letters received from the Chairman of the Cinema Commission (the Right Rev. Bishop of Birmingham), and others, expressing their interest in Dr. Kerr's paper, and regretting inability to be present.

Contributions to the discussion had also been received from Dr. Ernest Clarke, Mr. N. Bishop Harman, Mr. Colin

Bennett, and Mr. E. G. Kennard as follows :-

Dr. Ernest Clarke, M.P., F.R.C.S. : I have very little comment to make on Dr. James Kerr's excellent paper on "The Effect on the Eye of Varying Degrees of Brightness and Contrast." There is no doubt about the truth of his statement that extreme contrast between the brightness of an object and that of the general surroundings is most objectionable—in fact, it is absolutely painful to some people. Shrinking from the glare of light (for which I have had to invent a word, viz., photaugiaphobia, to distinguish it from the shrinking from ordinary light, *i.e.*, photophobia) has had of late years many more victims, probably due to sources of artificial light not being properly masked, nor properly diffused.* Naked incandescent or electric light should never be fixed on the eye line, but should be placed high up or low down, and then carefully shaded. The best form of illumination is a reflected electric light, but unfortunately the cost of this and its extravagance militates against its general adoption.

I agree with Dr. Kerr's remarks with reference to the cinematograph. Where flicker occurs it is, of course, extremely harmful. If trouble occurs in the better cinema where the flicker is absent, it is probaby due to the presence of astigmatism, which ought to be corrected with the proper glasses, or, as Dr. Kerr remarks, to the screen being too glary and the auditorium too dark.

Dr. Kerr's remarks with reference to the position of the screen and the person looking at it, are especially useful. There is no doubt that those sitting near to the screen get considerable eye-strain from the raising of the eyes, and also from the unnecessary accommodative effort, and I consider that under these circumstances no one should be allowed to look at a cinematograph screen nearer than 20 feet. The best position is in a gallery at the opposite end of the room.

Some people who can read a book with unglazed paper quite easily, suffer immediately from eye-strain with *glazed* paper.

Finally, there is one important fact we must not lose sight of. In our attempt to remove glare by diffusing the light, we must beware of lowering the light to such an extent that the illumination is not sufficient for our purpose, because in this latter case we introduce eye-strain.

Mr. N. Bishop Harman (*communicated*): I have been greatly interested in reading the proof of Dr. Kerr's paper on "The Effect on the Eye of Varying Degrees of Brightness and Contrast." Whether we live in the spacious times of unlimited evening illuminations of our towns, or in these days of darkness, the state of the streets of our big cities is proof positive that very little thought has been given to the attainment of a system of illumination which will be both effective and comfortable. In pre-war days the exposure of flaming arc lamps in rows in front of shops at very little above the level of the heads of the people was distressing to a high degree. No less troublesome, and much more dangerous is the bewilderment caused by the innumerable twinkling lights that surround one in the passage of a great darkened square or street. Trafalgar Square is a terrible place on a dark clear night when there is no haze to distribute the rays of the lights or deaden those at a distance. That such a state of affairs is quite unnecessary is proved by the recent changes in the street lamps in Marylebone. The effect of which is to reduce the specific intensity of the light, increase the luminous surface, and produce a delightfully soft glow at once illuminating and comfortable.

In the interests of traffic this change, involving the elimination of unduly bright sources of light, and violent contrasts in bright and dark areas, is welcome.

It would seem doubtful policy to attempt the prescription of any specific standards of lighting for general purposes. Minima are necessary ; but minima should not be allowed to become our maxima. The one thing that should be insisted upon is the relative illumination of the parts of the same place. Dr. Kerr has wisely insisted upon this as the chief factor for comfortable vision. I know of no more fatiguing exhibition than that of the optical lantern, whether it be with fixed pictures or with the cinematograph. The fatigue is produced by the exposure of the eyes to what is but a low degree of actual illumination, but one that is relatively high in the darkened surroundings of the screen. There is no real necessity for this excessive contrast. I have known lecture rooms in which the whole proceedings were carried out in the full light of day, and yet in these rooms, without any alteration or shading of windows or skylights, effective use was made of the optical lantern for lecture purposes. The arrangement was as simple as it was effective. The screen was fixed in the darkest part of room and surrounded with a deep black frame projecting forwards at right angles to the surface of the screen on all sides. I have seen the same plan adopted to make railway signals visible to drivers who approach them from the darkness of the tunnel. In the full light of the open space they would be invisible, but framed in this fashion the light can be picked up with ease.

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* See a contribution from the writer to the *Medical Press and Circular*, August 4th, 1915.

If, as is quite possible, the cinematograph should be introduced into schools for education purposes, some such arrangement for a daylight exhibition would be of great value. It would reduce structural alteration to a minimum, do away with blinds that get out of order so easily, and prevent fatigue from excessive contrast.

Mr. Colin N. Bennett (*communicated*): First, I wish to express my gratitude to the Hon. Secretary of the Illuminating Engineering Society for his cordial invitation to me to be present at the reading of Dr. Kerr's paper on the "Effect on the Eye of Varying Degrees of Brightness and Contrast." It is a great disappointment to be prevented by reasons of health from being present.

With almost all of the lecturer's remarks I am in full agreement. In one instance I should go farther than he does. The damage to eyesight resulting from the present practice of continuing kinema seating right up to within ten feet or so of the screen—especially where the hall is broad for its length—must be considerable, even for adults. I know of halls in London where the spectators in the front, second and third rows of seating, and in seats near the end of the rows, have to view the screened picture at an oblique angle of from twenty-five to thirty-five degrees with the picture plane. This is all wrong, and reflexly must do great damage to the industry itself.

The remarks upon arranging for a graduated diminuation of illumination between the outer vestibule of the kinema and the actual picture hall, also upon the necessity for providing and making use of dimmers for raising and lowering hall lights between pictures, seems to me highly important.

When it comes to dealing with the question of flicker brought about by the action of the rotating projector shutter, I think it might well be borne in mind that with the modern three-blade rotary shutter there are forty alternations of light and darkness upon the screen in each second of time, that is practically the same number as when burning a twenty-five cycle A.C. arc lamp in the open. In other words, at normal screen illumination flicker is quite unnoticeable.

Again, in considering the relation of eye-strain to discernment of fine detail, while a well-focussed projected kinematograph picture should be, and can be, quite sharp, in the sense of not being woolly or "fuzzy," it will not by its nature present any very fine detail to tax the resolving power of the eye when viewed from a reasonable distance, since the degree of enlargement of the original film picture (from under one inch in diameter to from twelve to twenty-four feet in diameter) has the inevitable effect of producing wide broad massed lights and shadows. These are admitted by artists to be the most restful to the eye.

The eye of a spectator of a kinematograph picture viewing a projected full size upon a sixteen foot screen, from a distance of fifty feet, is subtending an angle of view of about sixteen degrees, or a full picture angle in the artistic sense.

The spectator who watches a twenty-two foot picture from a distance of a hundred feet subtends a view angle of eleven degrees, still by no means so narrow an angle as to be fairly called a condition of concentrated light. Also, in a moving picture, the macula of the eye is not fixed upon one point of the screen all the while, but is kept moving slightly in a natural way with the movement of the characters or incidents of the picture.

With Dr. Kerr's discreet hint that at present the general intellectual level of the public kinema performance is not all it might be I am personally in full agreement, but the way to improve this is not, as some social reformers seem to think, by insisting upon the inclusion of a patchwork of disconnected, and in themselves "scrappy," so-called educational films, in what sets out to be an amusing picture programme.

On one point I do not agree with the lecturer. He evidently favours the compulsory illumination of kinema halls during the picture performance. Where this is attempted the result is to suffuse the hall with light of a widely differing tint from that of the arc light upon the screen. More or less of this light finds its way to the screen, and if it does nothing worse, invades the shadow portions of the image which take to themselves a more or less ruddy, or alternately a washed-out tone. You now have two lights of differing tint opposing one another upon the projection screen, and as a result, the want of chromatic correction of the eye feels it, and eye-strain and a glare effect are rapidly induced. If the picture hall itself is decorated in shades of lightish brown and red, it will reflect quite sufficient of the light coming from the screen picture to afford a satisfactory illumination.

I should like to add a word for the picture operator in his operating box or room, constantly subjected to eye-strain from the naked arc light, and from the light spot on the film in the gate, which by the nature of his calling he must watch continually. There are nearly ten thousand operators and assistant operators employed in picture theatres in Great Britain, and the compulsory use by them of viewing glasses or spectacles passing only light from about the region of the spectrum D to E½F would be a very quick and practical means of helping to save human eyesight.

Dr. Kerr is much to be thanked for the thorough-going way in which he has taken up the science of kinema lighting from the point of view of benefitting the public.

Mr. E. G. Kennard (*communicated*): I am sorry to be unable to be present at Dr. Kerr's paper, but enclose a few remarks on the subject of lighting in cinematograph theatres.

With regard to flicker, this has been largely eliminated in modern projecting apparatus by the use of the three-bladed shutter. The first shutter comes into operation to mark the change in the screen of succeeding impressions on the film, the other two shutters being placed equidistant from the first shutter, so as to cut the light off twice in succession while any one image is showing on the screen. The old arrangement only provided one shutter to cut the light off while the actual moment movement of the film took place.

Increased speed of projection also largely reduces flicker. "Jumping" on the screen (not to be confused with flicker) is found by some persons to be very annoying to the eyes. This is more noticeable at a short distance from the screen. The trouble is chiefly encountered with old films where the "sprocket-holes" have become worn.

With regard to the illumination on the screen even greater variations than that of 0·5—1·0 ft.-candles have been found to exist in any one subject. The usual practice in the operating room of a cinema theatre is to run at a constant current somewhere between the limits of 50 and 90 amperes, according to the size of the picture. It is much more difficult than is generally appreciated to maintain a steady arc with a heavy current and with the crater in the correct position, so as to give good illumination results. It is not therefore an easy matter to regulate the amount of light to correspond with the varying densities of the film. As it is also practically impossible to get enough light to show a dense film with a good screen-illumination, any attempt to work out to a definite value of screen illumination, within narrow limits, would not be successful.

The presence of smoke and fog in the hall also makes a large difference in the screen illumination, especially in a long building where the operating room is situated at the opposite end to the screen.

Dr. Kerr's remarks on metallic screens are borne out in practice, as the result is very unsatisfactory when the film is viewed from an angle.

Dr. C. W. KIMMINS (L.C.C. Chief Inspector of Schools) said that there was now in the Illuminating Engineering Society a body in a position to give expert advice in regard to illumination, and it should therefore be possible to incorporate this experience into bye-laws which would go a long way towards removing the prejudicial effects of cinema exhibitions on the eyesight of children. In this way it should be possible to render all such places harmless, or comparatively harmless from this point of view for people of all ages.

He hoped that Dr. Kerr would come before the Commission which was now dealing with this subject and give evidence with regard to some of the points dealt with in his paper.

Mr. A. E. NEWBOULD, speaking on behalf of the cinematograph industry, expressed the hope that the result mentioned by the last speaker would be arrived at with the assistance of men like Dr. Kerr, Mr. Harman and others. That would be doing a real service to the cinematogroph, of which it was badly in need. As to the moral question that had already been mentioned, there had been suggestions in regard to certain improprieties which had been attributed largely to the amount of darkness prevailing and regulations had been imposed to the effect that every portion of the auditorium must be clearly visible from any other portion. There was such a variety of officials in different places charged with the duty of seeing that this regulation was carried out, and such a variety of interpretations were placed upon the meaning of it, that it was almost impossible to carry on the industry and to satisfy the authorities. Therefore if it were possible to arrive at a formula for some standardised form of lighting which would not materially affect the value of the picture on the screen the trade would welcome it and gladly comply with a regulation which could be universally applied.

He had a message to convey from the Cinema Commission to the Society. First, he was to ask Dr. Kerr if he would give evidence before the Commission, and second, he was to invite the Society to nominate some suitable members to form part of the Committee charged to arrive at the desirable results which he had outlined, and which the last speaker had expressed. As a member of the industry who had a very large stake in it he would be only too glad to give every possible assistance.

Mr. F. W. GOODENOUGH (Chairman of the Council) promised that at the next meeting of the Council the question of the formation of a small committee to co-operate with the Commission in the manner indicated by Mr. Newbould would be considered.

He felt sure that the Society could do no more useful work than to assist in bringing about the establishment of reasonable and practical regulations for the lighting of cinematograph theatres.

Dr. F. W. EDRIDGE GREEN said that for the past twenty-five years he had considered it a fundamental principle of lighting that in order to see well with the centre of the retina the periphery must be stimulated. It was absolutely necessary that this physiological principle should be complied with in the cinema theatre, and therefore that there should be a reasonable amount of illumination in the auditorium without interfering with the picture on the screen.

It was chiefly in the poorer-class cinema theatres that flicker was noticeable and headaches prevalent; he had noticed that a number of such theatres had been obliged to close, presumably on the principle of the survival of the fittest. People who found themselves affected in the manner described stayed away or went elsewhere.

While he cordially agreed with the facts mentioned in Dr. Kerr's paper he took exception to some of the physiological explanations. There was no evidence whatever to show that the rods were light percipient organs, and this view was now expressed in leading text books on physiology. The retina must be regarded as a liquid photograph, the impression being created by the action of light on the visual purple.

Mr. E. T. SWINSON said that in London the theatres most patronised by children were the poorer ones where least provision was made for lighting or position. This was largely a question of finance so far as the position of the seats in respect to the screen was concerned, and he knew many a theatre in London where it was not unusual to find thes seats within 4 ft. or 6 ft. of the screen. Furthermore, the screen was at such an angle that it was impossible for the children to see the pictures properly even in most favourable circumstances.

Added to that was the fact that in this class of cinema the films used had already gone through various stages of use, and by the time they reached them were in the worst possible condition. Mr. Newbould had mentioned that the lighting question was now being tackled. That might be so in London, but he was not sure that similar instructions had been given with regard to provinicial theatres. In London the rule had been laid down that the theatre must be fairly well lighted. That had been done from the moral aspect, but incidentally it should also be possible to secure the result mentioned in the paper.

It was admittedly a difficult matter to apply a golden rule to theatres of this description, of whatever class and wherever they might be situated. It seemed to him, however, that the Commission might very well lay stress on the point that any regulation with regard to lighting cinemas should not come from the local authorities but direct from the Home Office, which had powers to make regulations standardising the minimum amount of light which should be provided in the auditorium.

Lieut. S. R. MULLARD, R.N.V.R., asked if Dr. Kerr could give any idea of the average time interval required by the eye to adapt itself from intense glare to darkness and vice versa. It was a matter in which he personally was very much interested because he had done a great deal of work in which very high power lamps were used and had found that the contrast in coming out of the laboratory in which arc lamps were burning, into the obscurity outside was so great that it took some minutes for the eye to adapt itself to the altered conditions. They made it a rule in the Ediswan laboratory that all very bright lights were switched off half an hour before the staff left the laboratory. Otherwise accidents might occur owing to the contrast of the darkened streets.

The matter was of interest with reference to the light source in the cinematograph lantern. The eye strain was unquestionably greatest when the ordinary arc lamp flickered or went out and restarted. In a large measure the flicker accounted for the variation in screen illumination.

He confidently hoped that before long these difficulties would be overcome by the introduction of a high candlepower " Pointolite " lamp for use in at least the smaller cinema halls, in place of the existing arc lamp. This new lamp, like the 100 candlepower lamp of similar construction, would be easy to operate and would give a perfectly steady concentrated source of light.

Mrs. M. A. CLOUDESLEY BRERETON said it was an important fact if, as stated, the films in the poorer-class cinemas were practically worn out. She hoped the Commission would make a note of that. It was, of course, a question of finance, but this should be the last direction in which an attempt should be made to save money, and there should be some very stringent rule made that after a certain period all films should be scrapped.

The second point she wished to refer to hinged on that. Some of the journalists present would remember that they were received a short time ago by Mr. Acland at the Imperial College of Science, and they were asked to interest the general public in the relation of science to industry.

The subject for discussion furnished an excellent example of a case in which the general public were vitally interested in the applications of science. It was particularly necessary to bring such matters to the notice of the workers of the country, and journalists could aid in making them widely known. If the Society could assist towards bringing about useful by-laws eliminating conditions in cinema theatres which were prejudicial to health it would do most useful work.

Mr. A. CUNNINGTON referred to the need for more precise definition of intrinsic brilliancy, as one of the factors causing glare. In the discussion on glare, which took place before the Society in 1908, a definition of intrinsic brilliancy was given in terms of candle power per unit of area. But area of what ? He understood that the projected area of the light source was meant. Prof. Morris apparently acted on this assumption in presenting his figures last year in connection with the half-watt lamp, but he was not quite sure himself that it was necessarily the projected area which should be taken.

In the case of illuminants, which consisted of a fine mesh of incandescent substance, it was impossible to distinguish the bright elements with the naked eye. The question arose, therefore, how the intrinsic brilliancy of metal filament lamps and gas mantles should be rated. Ought one to take the projected area enclosing the incandescent material, the actual glowing area itself, or a figure making allowance for the dark spaces between incandescent filament or fibre ?

Mr. J. G. CLARK, speaking on the question of uniformity in lighting, mentioned an experience in connection with a factory where the men habitually moved about with their work from place to place in the shops in order to get a change of intensity of light. In the same way, workmen had expressed a preference for movable lights so that they could vary the intensity of the light according to the work they were engaged upon.

With regard to the 3 candles per square inch mentioned in the paper, would the author in his reply make it clear how that was related to the position of the light to the eye. For instance, in the case of the meeting hall of the Royal Society of Arts, the average brilliancy was higher than 3 candles per square inch but the lamps were sufficiently out of the range of vision not to cause any trouble. It was a question that involved the angle of glare, *i.e*, the angle at which the line of glare should meet the eye.

Some four or five years ago, Mr. Mackinney and himself read a paper before the Society in which one of the illustrations showed a series of sources of light with shades and globes showing against dark and light backgrounds. The sources of light that appeared quite glaring against the dark background were by no means glaring against the lighter background. It showed that we must not be too close in our ideas as to permissible intrinsic brilliancy. Mr. Cunnington had referred to the mantle as a woven mesh. It was true that it was a mesh but if the mantle were looked at under a microscope it would be seen that the places where the meshes would be were filled with tiny fibres projecting from the fabric of the mantle, and these fibres, being fine, became intensely brilliant when the mantle was incandescent and practically filled up these meshes with light. Another effect that operated was that through the meshes could be seen the light surfaces of the mantle on the inside. The inside of the mantle was incandescent as well as the outside, so that the mantle had practically become a solid source of light. Thus, so far as the mantle was concerned there was question that the projected area represented the true intrinsic brilliancy.

Mr. A. P. TROTTER, referring to intrinsic brilliancy, said that some years ago he suggested before the Society that in dealing with intrinsic brilliancy, especially, with a metal filament lamp, they must not take a micrometer and measure the filament cold. That was not what was seen when the lamp was burning. By irradiation, the filament was ten times or more the width as measured cold, and that was what should be taken if anything at all were taken for measuring the area of the surface. But he did not know that we could have different figures like that : it would be necessary to take something like a total area surrounding the lamp and that was a very difficult thing to put into words. In any event, we must not take a micrometer measurement of the filament and say that that was the area.

There was a point with regard to school lanterns and screens. About 20 years ago he arranged a screen in a lecture room at Cape Town, and although he could not remember where he got the idea from he placed the screen up in a dark corner of the room in such a manner that practically the windows were not visible from it, and made the screen of transparent cloth—there was no better material than tracing cloth—and by placing the lantern behind the screen it was possible to work in daylight without the blinds pulled down and to see excellently. These methods seem to present distinct advantages when room was available for projection from behind the screen.

Mr. J. W. BARBER said that to arrange for the lighting of the auditorium of a cinema and at the same time not to interfere with the lighting of the screen was a somewhat difficult matter. The result of a lighter auditorium was a weaker picture, so naturally if an effective screen result be required any increase of auditorium lighting must be accompanied by a corresponding increase in the illumination of the picture. The two matters were therefore conflicting. It has been suggested that the standard value of screen illumination should be fixed at one foot-candle, but apart from the conflicting factor mentioned it must not be overlooked that certain points of projector construction have a bearing on the apparent illumination of the screen. The cinematograph projector is fitted with a revolving shutter, the obscuring arc of which varies very much in different makes of machines. Two machines may be working side by side and, leaving out any question of film density, one machine may easily require 25% more current to obtain an equal brilliancy of picture. He felt therefore that unless some consideration be taken of the shutter efficiency of the projector no formula would be equitable. Yet again the density of the film played its part, the density naturally varying according to the nature of the subject. He thought these practical difficulties, which necessitate intelligence on the part of the kinematograph operator, would almost prevent arriving at a standard value for the luminosity of the screen.

Regarding the permanent lighting of the auditorium, a considerable amount of time had been spent on an endeavour to arrive at a formula, as mentioned by Mr. Newbould, but it had been found very difficult to arrive at any figure that would satisfy everyone. The question of side lighting came into play, and if in a wide hall the lighting be increased to give some standard minimum of illumination in the centre portions, those patrons sitting at the side of the hall might be prevented from comfortably viewing the picture. He did not think there was any necessity to fix any figure for the illumination for the centre portions of the hall as during the projection of a picture, which in a modern cinema is but momentarily interrupted, the centre of the hall is fairly well illuminated by the beam of light from the lantern.

On the question of the distance from which a picture might be viewed without harm to the eyes he felt that no fixed figure could be taken without consideration of the screen dimensions. Figures of from twenty to thirty feet have been quoted as being the minimum distance anyone should be permitted to view a picture, but he had personally found that looking at the screen a distance away equal to its width no eye strain at all was suffered. Dr. Kerr made the interesting remark that should a certain small dot of an " i " in a newspaper be held at one foot distance and carefully fixed by the eye it would be found that the area, where vision is good enough to distinguish the form of the surrounding type, can be covered by a shilling. It occurred to the speaker that the question of the distance from which the screen might be viewed, without eye strain, could be worked out with these figures as a basis, remembering, however, that the eye did not attempt to cover the whole screen but merely concentrated on the animation of some particular object.

Mr. J. S. DOW said that although much of the discussion had turned on cinematograph theatre lighting, the principles referred to in Dr. Kerr's paper had a very wide application.

The recognition of the part played by adaption of the eye had led to a revision of our ideas of glare. He would like to see a detailed examination of the effect on capacity to see variations in light and shade, of variations in the brightness of the surrounding area. This would be a most useful piece of work, and would go far towards establishing the correctness of the suggested limiting ratio of 100 : 1.

In this connection he would like to make one enquiry, although he was afraid it would be difficult to give an exact reply. It was interesting to notice that minimum, the variation in brightness that could be just perceived by the eye (for example in a photometer) was approximately 1 in 100. Was there any direct relation between this value and the ratio of 100 : 1 which seemed to be the limiting contrast which the eye could comfortably sustain ?

He had made a number of measurements of the illumination of cinema screens and found that one foot-candle was a usual value. As regards Mr. Kennard's comments on this point he thought it should be made clear that the illumination specified should be obtained on the screen from a clear aperture, before the insertion of the film. If this value could be standardised it would go far towards securing good results. It was a question, however, whether too great a screen-illumination might not be as detrimental as too little, both by causing glare and by causing any flicker to be more readily perceptive.

The provision of a certain amount of illumination in the auditorium, without spoiling the image on the screen, required study. It should not be impossible, by proper direction of the light, to prevent rays straying on to the screen. By the aid of modern illumination-photometers all such matters could now be easily tested when any particular scheme was being tried.

Mr. L. GASTER said that he had much appreciated Dr. Kerr's paper, with its happy blend of physiological knowledge and insight into lighting problems. The effect of excessive contrast, as Dr. Kerr had remarked, had entered into many questions before the Society. For example, it had a marked bearing on the conditions of lighting in schoolrooms, where it was recognised that the illumination on the blackboard should exceed that for general purposes. Similarly in the factory it was now agreed that, generally speaking, very strong local lighting, with complete darkness in the surrounding area, was objectionable. One good feature of the minimum general illumination recommended in the Home Office Report was that it prevented excessive contrasts occurring in this class of work.

The conditions in the streets also furnished a good example of the objection to alternations of bright patches of light and obscurity. The changes now being introduced in the Metropolitan area, which would eliminate to a great extent the patchiness complained of, marked a great advance in this respect. It was to be hoped that after the war authorities would learn from present experience and be more ready to consider methods of diminishing the glare from very powerful lamps.

He also agreed with much that had been said on the subject of cinema lighting. Dr. Kerr had emphasised a most important point in drawing attention to the danger of eye-strain and the effect of continually gazing upwards, on children occupying the front seats. The minimum distance of children from the screen should certainly be specified.

He also agreed that in the case of children the duration of the performance should be limited. Another point to be noted was that grown up people understood what was conveyed by a picture much more easily than young children. In the case of the latter any want of clearness due to poor illumination or defective films was therefore particularly objectionable as imposing a strain not only on the eyes but on the mind. For the same reason he advocated that in the case of a young audience some preliminary explanation of the subject should always be given.

All these points were of special consequence in view of the great potentialities of the cinematograph as an educational medium. In the event of the bioscope becoming more widely used in the schools, the conditions should be very carefully supervised.

He also wished to support the Chairman of Council in welcoming the suggestion that a small committee of the Society should be formed to co-operate with the Cinema Commission in regard to proper lighting for screens, halls, &c. The Society had already formed standing committees on School and Library Lighting, which worked in co-operation with School Authorities and the Library Association. A similar commitee to deal with cinema lighting could easily be arranged, and the Council would doubtless be glad to render any assistance in this direction.

Dr. J. KERR, in replying, said the speakers had almost entirely confined themselves to cinema lighting, which he had taken as an illustration of the occurrence of strain and glare in the unadapted eye, or rather the dark-adapted eye, and where there were still great possibilities of improvement.

The glare of shops and of the streets was more serious as a general problem than the cinema, and one which might involve questions of accident, even of life and death. For that reason he had urged that a standard of three candles per square inch of illuminating surface should be the maximum permitted, wherever the eye had to encounter the light directly. The ideal of lighting seen in the glare and blaze of the Great White Way, with its blinking and eclipsing signs, is a fatiguing horror, offensive alike to aesthetics and hygiene.

The transition of retinal adaptation in passing from brightness to dark is quite slow, may go on for an hour or two. Although practically it is complete in half an hour, for some minutes, at any rate, the individual is almost blind from want of retinal sensitiveness. Transferred now with the eye adapted for dark and highly sensitive to a bright blaze, there is a slight protection through the almost instantaneous contraction of the pupil, which effort causes a sense of glare whilst it is fully maintained, until with adaptation of the retina in a minute or two it again relaxes.

Turning again to the cinema, on which there have been so many interesting points presented in discussion, especially as to the mechanism of the picture production. The machinery is a highly technical part which he left out of consideration, and taking the average screen brightness as one foot candle suggested that an additional light could be usefully employed in the auditorium, not merely for convenience, but also to prevent extreme dark adaptation, and contrast glare from the screen, or from turning up of lights. He had sat through a university lecture in Munich in the ordinary daylight, a lantern in a darkened room behind projecting microscope slides on the screen without any failure in appearance. The decoration of the auditorium should be graded from brightest to darkest near the screen. The screen itself might have some further screening at the sides and top. There should be indirect lighting from the back part of the ceiling, and no illuminating source other than the screen coming into the field of vision. Such details are largely matters of cost, and their feasibility can be usefully worked out by the Committee of the Society, which has been suggested.

The speaker was not one of those who think that the cinema has a great future as part of our ordinary educational apparatus. It is capable of useful application for research in the analyses of rapid changes and complicated movements, but its popularity with children is simply as a mental dissipation. It gives emotional stimulus without much effort. It is mainly destined to be a recreation and amusement, capable of harm if improperly used, but which should also be maintained as one of the pleasures of life, and made as refined and hygienic as possible.

The HON. SECRETARY made a few general remarks, expressing the indebtedness of the Society to Dr. Kerr for his Paper, and thanking the President for presiding at the meeting, despite the many claims on his time at the present moment.

In conclusion, the PRESIDENT announced that the next meeting would take place at 5 p.m. on Thursday, March 22nd, when a discussion on "Fluorescence and Phosphorescence and their use to produce Luminous Effects." would be opened by Mr. F. Harrison Glew.

THE LUMEN.

By A. P. Trotter.

The subject discussed at the last meeting of the Illuminating Engineering Society was the Lumen. I wish to add some remarks to those which I made on that occasion. The Lumen may loosely be called a unit of light. Scientifically it is the unit of luminous flux—I am inclined to agree with F. W. Willcox that it should be regarded as a quantity of light rather than an illuminating power or value. In the first place it is necessary to understand what the term is intended to connote, and then to define it carefully.

I may claim some acquaintance with the drafting of definitions. I was chairman of the nomenclature sub-committee of the British National Committee of the International Electrotechnical Commission. That nomenclature committee consisted of men of very diverse qualifications. One would prevent us from confusing a cut-out with a fuse, another guided us to distinguish between mutual induction and the coefficient of mutual induction another had strong views on load-factor but no effectual meeting was possible unless Dr. Silvanus Thompson was present. On that committee I learned all that I know about scientific definitions.

Some of the terms which we defined are in common use in engineering, but where they are loosely employed, definition is advisable. Others, like "efficiency" have been borrowed from ordinary language and have been given very precise scientific meanings; and others like "barretter" convey no suggestion whatever of their interpretation. Sometimes a definition, if it is to be within reasonable limits, can be understood only by those who are already acquainted with the subject, *e.g.*, magnetic susceptibility. We have now before us the term Lumen, and we are told that lamp-makers are going to reject the ancient but strictly Anglo-Saxon expression candlepower and that Lumen will be substituted in their price lists. A definition must be framed and we must consider whether we need follow the obscure academic phraseology of the new generation of American writers or whether words can be found which shall satisfy a scientific man, and may be used by an ironmonger's assistant to explain a Lumen to a Member of Parliament.

Prof. J. T. Morris gave a definition by which one of those who took part in the discussion was misled in two ways. That speaker thought that the length of a foot was a factor and that you can consider "Lumens in the direction you are using it." Mr. Willcox is very helpful, though he begins in a ponderous way. He says that the Lumen is strictly defined as the unit of Luminous flux, luminous flux being radiant power evaluated according to its visibility. (An elephant may be defined as a proboscidean pachydermatous mammal. A far better definition is: a square animal with a leg at each corner and a tail at each end.) After quoting this pedantic American definition he says in plain language that the Lumen is the unit quantity of light flowing from a lamp or luminous source. He does not add that the lamp should be half as large as a lump of chalk, but leaves the magnitude to imagination. Later on he "admits," though he has not suggested otherwise, that the Lumen is a pure numerical function of the mean spherical candlepower. Some people will wonder what an impure one would be like, and others will shy at "function" and fear that dI/dt is coming. But at last, stowed away in a parenthesis, we find the crisp statement: "the Lumen=12.57 times the mean spherical candlepower." This, of course, is not intended for a definition of a Lumen, but means that the number of Lumens emitted by a lamp is 12.57 times the mean spherical candlepower, as he clearly explains elsewhere.

That is plain enough. But the commercial man will say: "Why 12·57? Why not give 4¾ per cent. discount and say a dozen?" The explanation is that we are not considering the intensity of light emitted in any one direction as in the idea of candlepower, but emission of a quantity or a flood of light in all directions over the surface of a sphere. These last six words may not seem to be necessary, but they are needed to carry on the argument. The surface of a sphere of one foot or one inch or one arm length's radius is 12·57 square inches or square feet on square arm lengths.* We may afterwards slice the sphere into zones, but the primary idea is the sphere.

Here we are tempted to forsake Mr. Willcox and to adopt the definition proposed by Prof. J. T. Morris, and say that the Lumen is the flux of light received by a surface of one square foot, and having an illumination over its area of one foot candle. But this is a corollary rather than a definition. I think it is a mistake to confuse taking with giving, reception with emission. In my book on "Illumination" I fell into the opposite error of writing that the illumination *produced by* one candle at a distance of one foot is one foot-candle. A foot-candle should be defined as the illumination received perpendicularly on a surface at a distance of one foot from a source of one candle-power.* It is a good thing to bring in the idea of reception when speaking of illumination, but if the Lumen is to take an early position in our list of photometric magnitudes and units, we must not allude to the foot-candle too soon.

Having accounted for the appearance of the numeric 12·57, it does not seem necessary to bring in 4π. Even if we explain that π means 3·14159 and is the measure of the circumference of a circle of unit diameter we have a long way to go to show how the surface of a sphere is calculated. A definition should contain as few terms as possible requiring explanation, but it may make assertions which are not self-evident. Dr. Silvanus Thompson* deduced from the American definition that one Lumen was $1/4\pi$ of the whole light emitted from a spherically uniform source of light giving one candle in every direction.

Working on this, we may substitute 0·0795 for $1/4\pi$ and take 0·08 as near enough for practical purposes, and omit the words "spherically uniform," since they are implied in what follows. This brings us very close to Mr. Willcox's parenthetical definition, and we may say that *one Lumen is 0·08 of the whole light emitted from a source giving one candle in every direction.* Some such word as "quantity" is needed. Dr. Silvanus Thompson used "the whole light"; the academic expression of the text book and lecture room is "flux of light."

The question will next be asked:– "Why not candlepower?" Putting aside the difference between an intensity and a quantity, the answer is: "Candlepower is a measure in only one direction; in many lamps very different candlepowers are emitted in different directions; the Lumen gives a sort of average." An intelligent man will at once form in the back of his mind an idea of what we call mean-spherical candlepower, and he will say: "Why not state the average candlepower?" Why not, indeed? This is rather a puzzler. Prof. J. T. Morris gives what is probably the trade reason, namely that a lower rating would have to be admitted, and an ordinary so-called 16 candle-power lamp would give 12½ average candle-power. Mr. Willcox as a trader does not allude to this climb down, but after announcing by a head-line, "Lumen *versus* spherical candlepower," says that mean spherical candlepower is a mouthful, is too cumbersome, and its abbreviation M.S.C.P. is more or less cryptic.

Let us be frank. Let us say that we really mean the average, but by multiplying by 12·57 we obtain a unit which readily lends itself to, and simplifies the calculation of illumination.

It should also be explained that what is really wanted is illumination, which is measured in foot-candles, and that, as Mr. Willcox suggests, if a floor is to be illuminated,

$$\frac{\text{Floor area in sq. ft.} \times \text{foot-candles}}{\text{Net lumens per lamp with its shade}}$$

gives the number of lamps required for that floor.

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* Fleming has shown that the factor for reducing the horizontal candlepower of a vertical straight parallel filament lamp to mean spherical candlepower is $\pi/4 = 0{\cdot}7854$. The M.S.C.P. of a 16 c.p. lamp is therefore 12·57, and this multiplied by 12·57 is 158. The lumens emitted by a straight parallel filament lamp are therefore 9·875, say ten times the horizontal candlepower.

* This gets rid of the word "falling" which I used in *The Illuminating Engineer*, Vol. VII, p. 341.

* *Illum. Eng.*, Vol. VII., p. 351.

THE LUMEN AS A MEASURE OF ILLUMINATING POWER.

By Professor A. Blondel.

I have read with great interest the contributions of Professor J. T. Morris and Mr. F. W. Willcox, whose references to my work I gratefully acknowledge. The latter has treated the question of the use of the Lumen in a manner so very clear, complete and persuasive that he does not leave a great deal to be said by those who support his views. The impression I have received on reading his remarks leads me to hope that he will succeed in convincing those engineers who have not yet appreciated the utility and practical convenience of the Lumen.

Professor Morris has also brought forward very clear and convincing arguments, and his comment regarding the inconvenience of the mean spherical candlepower for sellers of electric lamps is well worth consideration.

As Mr. Willcox kindly recalls, my proposals in regard to this matter were made more than twenty years ago.* I hope readers will bear with me, while I review some recollections of the first steps in the development of the now well-established unit, the Lumen. In 1893 I was first interested in the subject in the course of my experience in lighthouse work, which led me to regard the conception of flux of light as a matter well deserving investigation. I then formed the opinion, to which I still adhere, that this is the *only* basis on which the characteristics of electric projectors can be properly understood and their relative illuminating value adequately represented.

I subsequently found, in studying street lighting, that it was of considerable practical utility to work with flux of light, which can be measured as the product of the illumination and the area of surface illuminated. This aspect of the matter attracted the attention of Mr. John Hesketh, Electrical Adviser to the Queensland Government, who took the trouble to translate and publish in *The Electrician* two contributions which I had myself published on this question in 1895*.

Those who are sufficiently interested to look up these contributions will find that I discussed not merely the conception of the flux of light, but the definition of the Lumen; also that I described an instrument termed a "Lumen-meter," and designed for the direct measurement of the flux of light from a source. The methods then described are identical with those now generally adopted for the rapid calculation of the average illumination on large surfaces in rooms and streets, and are based on a knowledge of the flux of light derived from various types of lamps.

In the first of these contributions I proposed to adopt the Lumen and the lumen-hour as practical units. Unfortunately at the time when these ideas were first publicly presented they appeared premature. The scientific and technical education of engineers had not reached the present stage; it had not yet become usual to determine the polar curves of lamps in the laboratory and to present the results in an industrial form similar to that illustrated in Mr. Willcox's paper.

Thanks to the late Prof. Hospitalier's able support the International Electrical Congress of Geneva (1896) officially accepted the "lux" and the "lumen" and the Laboratoire Central d'Electricité, under the direction of Prof. Paul Janet, has, from that time up to the present, employed these units in all tests on arc lamps.

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* Mesures de l'Intensité lumineuse moyenne sphérique (*l'Eclairage électrique*, 1895); Unités Photométriques (*l'Eclairage électrique*, 1895. translated in *The Electrician*, 1895; Rapport sur les unités photométriques au Congrès Photométrique international de Genève, 1896; Théorie des projecteurs électriques (*Industrie électrique*, 1894), &c.

* l'Eclairage public par les lampes à arc (Part I. *Génie Civil*, Part II. *Revue Technique* Paris, 1896; translated in *The Electrician*, Vol. XXXV., p. 846, *et seq.*).

New units only slowly become familiar, and in this case were handicapped by the unfortunate inspiration which led the German engineers to create a "Hefner Lumen," having as its base the Hefner unit of intensity.

Illuminating engineers owe a debt of gratitude to the American Illuminating Engineering Society for having taken up this question in such a systematic manner during the last few years, and presented through its Committee on Nomenclature and Standards such a lucid series of reports. In the most recent report interesting additions are made to the system of units, notably the adoption of the "lambert" as the convenient unit of brightness; I myself recently proposed to complete the series of units by the "phot"—a unit of special interest in view of the fact that the milliphot is almost equal to the foot-candle.

The definition of the "phot" and the "lambert" has only become practicable since our friends in the United States selected the centimetre instead of the metre as the unit of length in photometry.

The Lumen has thus been brought before the notice of engineers in a continually improving form, and I have no doubt that the discussion of the Illuminating Engineering Society will be successful in removing the last objections and in convincing English engineers of the desirability of simplifying photometric measurements and placing illuminating engineering calculations on a sound and scientific basis.

Moreover, as I have shown in the contributions referred to above, it is very interesting to profit by the analogies between the photometric system of units applied to the study of distribution of light, and the units employed in the solution of problems relating to magnetic and electro-static fields.

Thanks to the happy agreement between the three national laboratories in England, France, and the United States on a common international unit of light, these three nations will eventually impose the international candle and Lumen on the rest of the world: even should the Hefner Lumen continue a separate existence it is easy, by the mere use of a numerical coefficient, to pass from one system to the other and thus render comparable the results presented in all countries.

The introduction of the "Half-Watt" lamps furnishes an additional argument in favour of the adoption of the Lumen. I myself have several times experienced disagreeable surprises in purchasing such lamps, anticipating a certain horizontal candlepower and subsequently discovering that the rating referred to candlepower in a vertical direction. It is desirable to avoid all such confusion by rating lamps in terms of their luminous flux.

For all these reasons I hope that the discussion now in progress will induce my English friends to adopt the proposals of the Illuminating Engineering Society in the United States, which have already received a most favourable reception in France and have now also received influential support in England.

CORRESPONDENCE.

THE DEFINITION OF THE LUMEN.

SIR,

The full discussion on the Lumen as a Measure of Illuminating Power in the last issue of the ILLUMINATING ENGINEER does not leave a great deal to be said on this subject. The arguments put forward in the Editorial remarks in that issue * are, from a scientific standpoint, very weighty and cover the ground pretty fully.

There are, however, several points in connection with the definition of the lumen, and its popularisation, that require to be made clear.

First it should surely be recognised that the choice of units and framing of definitions is essentially a scientific

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* *Illum. Eng.*, Jan. 1917, pp. 2—4.

matter, and, as stated in the Editorial referred to, should be determined with a view to the future and the needs of a science, and not in deference to the "man in the street." It is therefore important that those engaged in the search for a suitable definition of the lumen should be quite clear whether they are attempting to frame a scientific definition, or merely drafting a convenient method of conveying the relation between lumens and candlepower for popular use.

In my opinion, the strictly scientific and final definition is best not attempted as yet. For the time being it is necessarily based on the international candle, and the latter must first be defined in any system of units. At present it appears best, therefore, to define the lumen as the flux of light emitted by one candle, operating over unit solid angle ; and to add as a corollary, when defining the foot-candle, that a lumen is equal to the flux of light received by an area of one square foot illuminated with an intensity of one foot-candle. These two definitions are mutually consistent. There is not the least doubt as to the meaning of the lumen. Its value is unaffected by the choice between the foot and the metre as the unit of length, but naturally depends on the unit of candlepower adopted (now the same in Great Britain, France and America).

As regards popular explanation, there are two distinct objects to be achieved. We should state in round numbers the numerical relation between the average candlepower and the lumen, and makers of electric lamps may follow this up by pointing out that for ordinary metal filament lamps the value in lumens is roughly ten times the former candlepower (horizontal) rating.

We should not, however, stop after defining the numerical relation. With a view to the future it is most desirable that people generally should understand the conception of flux of light and should realise that flux, being the product of candlepower and a solid angle, is something different from candlepower alone. There is some danger that mere numerical ratios, especially when coupled with a reference to point-sources, or sources radiating uniformly in all directions, would foster incorrect ideas regarding the lumen. It might be assumed, for example, that rating in lumens available from a lamp could be only accurately applied when one was dealing with a point of light, and with uniform radiation in space. This of course is not the case. The great advantage of lumen-rating is that it is independent of these limitations.

Numerical relations, therefore, must be supplemented by explanations of the nature of the lumen, and, to my mind, the easiest way to approach this matter is by proceeding to the second alternative definition of the lumen in terms of a surface one square foot in area receiving one foot-candle. To this might be added a series of practical examples.

I lay stress on this point because there is already a tendency to assume that the change to lumen-rating merely means using average candlepower, but multiplying it by the factor 12.57. When we pass to the applications of lumens to calculations we realise at once that the change goes much deeper than this ; and that it is dictated by fundamental scientific considerations and not only by the fact that it happens now to be a convenience to lamp-makers in enabling them to cut adrift from the delusive unidirectional rating. The change is desirable as a convenience to illuminating engineers and is supplementary to existing methods of rating lamps in terms of watts or gas consumption.

I am, etc.,

AN ENGINEERING CORRESPONDENT.

RATING OF ELECTRIC LAMPS : TOTAL WATT-RATING AND LUMEN-RATING.

SIR,

With reference to the discussion on the use of the lumen in rating electric lamps I should like to correct one misconception that appears to be prevalent, namely, that rating in lumens means the exclusion of watt-rating.

The fixed practice of rating in total watts has been found very satisfactory and it is not proposed that this will be discontinued. It is merely proposed that where specification of luminous values is desired, these should be expressed in lumens instead of in candlepower, this avoiding the misunderstanding resulting from uni-directional rating in candlepower. Rating in lumens is thus supplementary to total watt-rating. The whole question was discussed before the Illuminating Engineering Society in 1915. *

Yours, etc.,

F. W. WILLCOX.

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* *Illum. Eng.*, April, 1915.

OBITUARY.

PROF. DR. FRIEDRICH ERISMANN, OF ZURICH.

From a recent copy of the "Zeitschrift für Schulgesundheitspflege," of which he was editor for a dozen years, we learn of the death of Prof. Dr. Friedrich Erismann, of Zurich.

Professor Erismann was a contributor to the proceedings of the Illuminating Engineering Society, and took part in the discussion on the Natural Lighting of Schools in 1913. He was born in 1842, the son of a Swiss pastor. He originally intended to work as an ophthalmologist, and took for his degree thesis a work on toxic amblyopia. Settling in Petrograd in 1869, he became interested in myopia and its causes, and from this to hygiene in general, becoming one of the first authorities on school hygiene. He was invited to the Chair of Hygiene at Moscow in 1881, and there established a laboratory from which issued many papers on ventilation and illumination.

He published about 140 papers, half in Russian, dealing mainly with artificial lighting and its effects on the atmosphere, shadows and their results, the distribution of lighting, and the orientation of buildings. He had strong opinions on the hygienic value of indirect illumination, recommending it for school use, the minimum standard for school which he suggested was 2·5 foot candles.

Finally, in 1894, he settled at Zurich, where he identified himself with all kinds of hygienic progress till his death at the age of 73.

We note with regret the death of Sergeant A. Lawton-Jones, who was killed in action on September 8th, in his twenty-third year. His commanding officer stated that he was always ready to do his duty, and more than his duty.

Mr. Lawton-Jones was a member of the Illuminating Engineering Society, and was formerly in the employ of the General Electric Co.

He will be greatly missed by his colleagues.

We understand that Mr. E. A. Nash, who was formerly associated with the Faraday House Electrical Engineering College, is now serving with the Colours as a Sub-Lieutenant in the Royal Naval Volunteer Reserve.

PROFESSOR S. A. RUMI.

Our readers will learn with regret of the sudden death of Professor S. A. Rumi, who passed away on January 8th, at the age of 64 years. Professor Rumi was an active Corresponding Member of the Illuminating Engineering Society, and took part in a number of discussions on photometry and lighting problems.

In his own country he was well known in electrical circles. Born at Novara in 1853, he graduated at the Turin Polytechnic at the age of 21, and was afterwards appointed Professor at the Physical and Technical Institute of Sassari. He subsequently collaborated with Prof. Pacinnotti in some of his experiments, and ultimately migrated to Genoa, where he became President of the Ligurian Section of the Associazione Elettrotecnica Italiana.

He had wide interests and was associated with many other scientific bodies and took a prominent part in the International Electrical Congress at Turin in 1911.

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DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH.

Standing Committee on Glass and Optical Instruments.

The Advisory Council of the Government's Department of Scientific and Industrial Research have added to the list of their technical Committees a Standing Committee on Glass and Optical Instruments. The membership of the Committee is at present as follows :

Professor H. Jackson (Chairman), Mr. Conrad Beck. Professer C. V. Boys. F.R.S., Mr. F. J. Cheshire. Mr. A. E. Conrady, Mr. A. S. Esslemont, Mr. J. W. French, Dr. R. T. Glazebrook. F.R.S., Sir Howard Grubb. F.R.S., F.R.A.S., Mr. E. B. Knobel, F.R.A.S., Dr. T. R. Merton, Professor J. W. Nicholson. D.Sc., Captain Creagh Osborne, R.N., Mr. H. J. Stobart, Mr. J. Stuart. Mr. M. P. Swift. Mr. William Taylor, Mr. F. Twyman, Lt.-Col. A. C Williams, Mr. W. F. J. Wood.

The Committee met on December 11th and, having regard to the urgency of the problems requiring investigation in respect of these essential industries, appointed a series of Sub-Committees to which various special problems were referred. Among these problems the more important are :—

(A) Raw materials for glass and glass making : (B) Optical properties of a large range of glasses ; (C) General physical and chemical properties of glass and glassware for scientific and industrial purposes ; (D) Testing and standardising of glassware ; (E) Workshop technique : (F) X-ray glass apparatus ; (G) Optical calculations and lens designing ; (H) Optical instruments ; (J) Translation of foreign works on Optics.

This brief description indicates certain lines of investigation which have been brought forward. The Standing Committee does not propose to limit itself to these subjects but is prepared to consider and report upon the necessity for investigation in other directions, relevant to its terms of reference. Manufacturers who have experienced difficulties requiring investigations for their solution in connection with the subjects of glass and optical instruments, or who desire to make suggestions for special researches on these subjects, are invited to communicate in the first instance with the Secretary of the Research Department, Great George Street, Westminster, S.W., who will direct the correspondence into the appropriate channels for attention.

BOARD OF SCIENTIFIC SOCIETIES.

Report of Committee on National Instruction in Technical Optics.

A sub-committee, consisting of Mr. Conrad Beck, Mr. F. J. Cheshire, Mr. E. B. Knobel, Sir Phillip Magnus, Prof. H. Jackson, and Prof. A. Schuster, has issued a Report emphasising the urgency of better facilities for instruction in technical optics. Years must elapse before the full results of any steps now taken will be realised.

Optical processes and manufacture are of direct interest to many branches of science. While it may be impracticable to evolve a complete organisation for the study of the subject at once, steps should be taken immediately to meet immediate requirements and to cover the transition period.

The chief suggestions in this direction set out in the Report of the sub-committee are as follows :—

(1) The appointment of a supervising representative Council.

(2) The appointment, under the proposed supervising Council, of an administrating Director with special duties during the transitional period, which will include advice to the trade and the organisation of the different parts of the curriculum.

(3) The translation of suitable works and the abstracting of other important publications on Technical Optics.

(4) Pending the erection of a suitable building the organisation of day and evening classes at the Northampton Institute, and arrangements for higher instruction at some other institution of University rank.

ERRATA.

Illuminating Engineer, January, 1917, p. 7, column 1, line 8 : *For* "Mr. Harry E. Jones, Chairman of the newly-formed National Gas Council," *read* "Mr. Harry E. Jones, President of the newly-formed National Gas Council."

P. 34, column 2, line 9 : *For* "The suggestion had also been made that lamps might be most useful . . . ." *read* "The suggestion had also been made that lamps might be marked in lumens per watt. This would be most useful . . . ."

The
ILLUMINATING
ENGINEER

ELECTRICITY · ACETYLENE · OIL · GAS

Edited by
LEON GASTER

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EDITORIAL.

Fluorescence and Phosphorescence and their use to produce Luminous Effects.

To those concerned with lighting problems there has always been a fascination in the effects of phosphorescence and fluorescence and their possible future application to produce a "cold" self-contained source of light, capable of giving a luminous effect for a limited period without extraneous stimulation. Anyone who has studied these phenomena cannot but be struck by their intimate relation to the fundamental principles of light-production; we seem to get here, as it were, a glimpse into the complex motions of atoms and electrons by which light vibrations are set in action and to touch upon the underlying processes on which the action of illuminants is based. The subject is therefore of great scientific importance, and the discussion opened by Mr. F. Harrison Glew at the last meeting of the Illuminating Engineering Society (see pp. 72—83) should be read with deep interest.

The matter was discussed from three distinct aspects. Mr. Glew gave an explanation, accompanied by interesting demonstrations, of the nature of phosphorescent effects, as exemplified by their use in the form of luminous paint. Mr. A. Blok discussed the measurement of brightness of phosphorescent and fluorescent materials, and Mr. Dow dealt with some of their possible applications.

Apart from their interest from the purely scientific standpoint, these effects have already found practical application in the form of luminous paint. It has long been known that many such substances would glow after exposure to light, but the luminosity thus excited is somewhat transient, and therefore attempts have been made to produce continuous stimulation giving a more sustained effect. The most successful method of stimulation appears to be by incorporating in the light-yielding material (generally zinc sulphide) a small percentage of radioactive substance. The "alpha rays" emitted by this substance excite a steady luminosity, and the intensity and duration of the brightness produced varies according to the composition of the sample. It was stated, however, that the order of brightness met with in commonly used materials may attain that of full moonlight on a white surface (about 0·02 foot-candles). It is not uncommon for the brightness to fall by 50 per cent. in the course of a year, but in some preparations containing a high radium content, the decay may be very much more rapid.

On such points little reliable information has yet been published, but it was intimated that tests are being made and fuller information may be available after the war. Mr. Blok and Mr. Paterson described various methods of measuring the relatively feeble luminosity of such substances indicating some of the difficulties which photometry presents at such low illuminations, and with more or less monochromatic light. In these circumstances all the peculiar characteristics of the eye at low illuminations are very evident, and this naturally makes it difficult to make comparisons on small samples. Nevertheless it is clear that expert photometry is a great aid in such investigations and may bring to light many unsuspected effects. It is somewhat singular that while so much has been done on the chemical and physical side, very few measurements of the actual luminosity, the factor of greatest practical importance, have been published. Here surely is an ideal opportunity for the chemist and the expert photometrist to co-operate. In such investigations, however, it appears necessary to bear in mind the physical peculiarities of the eye referred to above. Some observers have found, for example, that a small patch of feebly luminous material appears very much less bright than a large area; it would therefore be desirable, wherever possible, to work with surfaces of fairly large size. Another point to which attention has been drawn is the difficulty experienced by the eye in bringing the green, and especially blue and violet, light to a focus at distance exceeding a few feet. While this effect is not of very great importance so long as the paint is used for objects seen at close quarters (small figures on dials, &c.), it would be helpful, with a view to the use of such materials on objects to be seen at a distance, if substances giving suitable phosphorescence in other regions of the spectrum could be produced in sufficient quantity.

The "self-luminous" paints, containing radium, have already proved their utility in many special directions. In view of the effect of the radium content on expense and on the useful life of such substances it seems very important to determine not only the brightness and life of different specimens but the order of brightness necessary for different purposes.

In the case of ordinary luminous paint, prepared to glow after exposure to light, we have little information as to the brightness attainable with different excitations, and the time during which an effective luminosity persists. Bearing in mind the comparative cheapness of such material, it seems desirable to have fuller information on these points. Doubtless the preparation of such materials is as yet in its infancy, but already attempts are being made to utilise them for coating objects which it is desirable should be seen in the dark ; it has been suggested, for example, that during the darkened condition of the streets luminous paint might be applied to render kerbs, lamp-posts, &c., readily distinguishable. It would be very useful if specific data on this point could be obtained. Once it was shown that the brightness attainable, and the period of its duration, were sufficient to give a distinctly useful effect, the way would be opened up for the practical exploitation of such substances on a larger scale, and a great impetus would be given to the systematic study of such substances and their commercial exploitation.

Of equal interest is the possible exploitation of these substances to produce colour-effects. The demonstrations by Mr. Landau in the course of the discussion served to show what a variety of colour can be obtained by the stimulation of various substances under the light from an iron-spark. The range of colours attainable that will "phosphoresce" (*i.e.*, continue to give light after excitation), with sufficient brightness to give a striking effect, is more limited, but even here quite beautiful effects have been produced. While, for the present, strictly utilitarian applications of phosphorescent substances naturally must receive prior attention, their use for artistic and theatrical displays, for luminous signs, &c., will doubtless be studied more fully after the war.

There are, of course, many other possible applications of phosphorescence and fluorescence. In the screens used with Rontgen ray apparatus we have another familiar example of the utility of the fluorescence effect. Here, again, there seem opportunities for exact methods of measurement in judging the deterioration of such screens in course of time and in determining whether any apparatus is working at its proper efficiency. There are also the interesting series of effect in gases, illustrated by Mr. Landau by the exhibition of the "shaker" tubes containing neon gas.

To many of the most important applications of such substances namely, those in connection with the war, we cannot refer at the present moment, but we hope that at a future time interesting particulars will be forthcoming.

Enough has, however, been said to show that the whole subject of phosphorescence and fluorescence provides a most fascinating field for study. We commend the subject to the notice of members of the Illuminating Engineering Society.

Scientific Research in the United States.

It will be recalled that a few months ago we drew attention to a Report issued by the Science and Industry Commonwealth Advisory Council in Australia, of the steps being taken for the promotion of industrial research in that country.*

We have now received a copy of the Memorandum prepared by Mr. Gerald Lightfoot on "Organisation of Scientific Research Institutions in the United States of America," after his visit to that country in February and March, 1916. Following this visit Mr. Lightfoot accompanied the Rt. Hon. W. M. Hughes, Premier of Australia, to this country for the purpose of studying conditions of research here, and promoting co-operation in the scheme for the development of a Federal Institute of Science and Industry in Australia, on which he addressed the Circle of Scientific, Technical and Trade Journalists on May 16th, 1916.† Mr. Lightfoot's report is opportune as giving a concise summary of the machinery, both State and privately aided, for this purpose in the United States, and should be of great interest to many of our readers.‡

A broad distinction is drawn between National and State Institutions, privately endowed institutions, and industrial laboratories. Among seventeen State Departments that are more or less concerned with research, we note particularly those dealing with Forest Service, Public Health, Animal Industries, Entomology, and the Bureau of Soils, Chemistry, and Biological Survey. In addition there are such institutions as the Bureau of Standards and the Bureau of Mines. The former, to whose publications we have often referred, has an annual expenditure of £125,000, and much of the information obtained is placed freely at the disposal of the world, the system of distribution being, as we have recently had occasion to remark, extremely well organised.

Of especial interest is the equipment of agricultural stations and colleges throughout the United States. It is stated that the property and endowments of such colleges exceeds in value thirty million pounds. The number of students is about 70,000, and one can readily imagine the effect of this steady influx into agriculture of trained men.

Behind such State-aided institutions are the many well-equipped Universities and privately-endowed institutions (such as the Carnegie, Mellon, and Rockefeller institutes). In addition it is by no means unusual for the annual expenditure of many of the well-equipped industrial laboratories to reach £20,000—£60,000 per annum. Such expenditure would be a revelation to most manufacturing concerns in this country. We do not doubt that Mr. Lightfoot's report will be read with close interest in Australia as well as in this country, and we see already, in the recent formation of the Imperial Trust for the Encouragement of Scientific and Industrial Research, gratifying evidence that the need of promoting scientific method and experiment on a far larger scale is recognised by the authorities. We trust that the efforts of Mr. Lightfoot and others who are working in a similar direction in Australia will find generous support.

LEON GASTER.

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* *Illum. Eng.*, Nov. 1916, p. 333.

† *Illum. Eng.*, June, 1916, p. 199.

‡ Memorandum on the Organisation of Scientific Research Institutions in the United States of America, presented by Mr. Gerald Lightfoot, M.A., F.S.S., to the Commonwealth Advisory Council of Science and Industry, 314, Albert Street East, Melbourne, Australia.

TRANSACTIONS

OF

The Illuminating Engineering Society.

(Founded in London, 1909.)

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

FLUORESCENCE AND PHOSPHORESCENCE AND THEIR USE TO PRODUCE LUMINOUS EFFECTS.

(Proceedings at a meeting of the Society held at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, W., at 5 p.m. on Tuesday, March 22nd.)

A MEETING of the Society took place as stated above, on Thursday, March 22nd, at 5 p.m., the chair being taken by Mr. F. J. CHESHIRE (Director of Optical and Glassware Munitions, Ministry of Munitions of War).

The minutes of the last meeting having been taken as read, the President called upon Mr. F. HARRISON GLEW to open the discussion on "Fluorescence and Phosphorescence and their use to produce Luminous Effects." Mr. GLEW'S remarks were illustrated by a variety of experiments, showing the excitation of luminescence in zinc sulphide and other materials by aid of the tungsten arc, the production of phosphorescence in certain crystalline materials, &c.

In the subsequent discussion, Mr. J. S. Dow, Mr. A. BLOK, Mr. A. L. LANDAU, and Mr. C. C. PATERSON took part. Mr. Dow pointed out the close relation existing between the effects of these feebly luminous materials, and the condition of the eye at weak illuminations; Mr. BLOK and Mr. PATERSON summarised some of of the difficulties in the photometry of such materials, and described some apparatus devised for this purpose; Mr. LANDAU showed a number of experiments, illustrating the production of fluorescence in various colours by the rays from a spark between iron electrodes. Apparatus was also exhibited by Messrs. H. F. Cox & Co.

The Chairman, in winding up the discussion and thanking Mr. Glew and others for their demonstrations, pointed out the importance of investigations in this comparatively unexplored field, and expressed his appreciation of the fact that the matter was receiving attention at the hands of the Illuminating Engineering Society.

It was announced that at the next meeting, to take place in May, there would be a discussion on "Economies in Lighting in Relation to Fuel-Saving."

FLUORESCENCE AND PHOSPHORESCENCE AND THEIR USE TO PRODUCE LUMINOUS EFFECTS.

(Introductions to a Discussion at a meeting held at the House of the Royal Society of Arts 18, John Street, Adelphi, W., at 5 p.m., on Thursday, March 22nd, 1917.)

I.—THE PRODUCTION OF FLUORESCENT AND PHOSPHORESCENT EFFECTS.

By F. Harrison Glew.

In general illuminants operate by incandescence, *i.e.*, the production of light through high temperature. Other processes, not involving the action of heat, are termed luminescence, and are illustrated in a few illuminants, *e.g.*, the mercury vapour lamp and, to some extent, in flame arcs.

To illuminating engineers the processes involved in luminescence have therefore a direct interest, apart from the wider aspects of these phenomena.

One of the most familiar examples of such effects is the firefly, the luminous efficiency of which is believed to be far higher than that of any existing illuminant and other insects and marine forms of life have similar properties. The production of light appears to be due to chemical action. The glow of phosphorus (from which the term " phosphorescence " is derived) in the dark is due to slow oxidation, and luminosity may also be produced by the oxidation of pyrogallic acid and other organic materials. Such effects are termed " chemi-luminescence."

" Tribo-luminescence " is the term applied to luminous effects produced by friction, *e.g.*, by rubbing or scratching certain crystals (quartz, sugar, fluorspar, etc.).

Possibly the production of light in these cases may be ascribed to the electrification of the material by friction. I am showing an experiment to demonstrate how easily such electrification may be produced. If a pair of silk ribbons are held up side by side, and then briskly rubbed with a rubber or ebonite sleeve the ribbons separate, showing that they are electrified (Experiment); this simple apparatus is capable of detecting the presence of radium as the air becomes a conductor of electricity, being ionized.

Pyro-luminescence is a term applied to describe the luminescence of certain crystals under the action of heat. Spodumene, for example, which has been placed in proximity to strong samples of radium becomes intensely luminous, giving a strong orange glow when placed in boiling water. Here we have an example of the transformation of stored radioactive energy into light, in accordance with Stokes' Law; in no case is light actually stored as such.

When the impact of visible light on a substance produces luminosity of a different (by " Stokes' Law " a lower order) colour, this is termed " fluorescence." The effect is exhibited by fluorspar and similar crystals. When the effect still persists after the cessation of the stimulating action so that the luminosity persists in the dark, it is termed " phosphorescence." A good example of fluorescence is to be found in the transformation of violet and ultraviolet light into visible red rays by the rhodamine reflector, used with the mercury lamp to modify its spectrum. Fluorescence may be excited by other forms of radiation, for example, that emitted by an X-ray tube, or the spark from an induction coil.

Many crystals and precious gems will become luminous in these circumstances, and the method has been applied to distinguish the genuine diamond from imitations. A real diamond will fluoresce when exposed to the alpha rays from radium, and there are some diamonds, though not all, which will also fluoresce under the action of ultra-violet light. (Experiment).

By the suitable selection of materials a great range of fluorescent colours can be obtained; there are, however, fewer substances which will phosphoresce strongly in the red and yellow end of the spectrum. The colour excited by fluorescence may be modified by mixing the material with other substances which themselves fluoresce by the light of the primary fluorescing material.

Luminous paints which, after exposure to daylight, retain luminosity for some time in the dark, have been known for many years. Crystals of calcium sulphide phosphoresce blue, zinc sulphide green; other materials give a less luminous effect in yellow, red, and other colours. The manufacture of such substances and ingredients used to accentuate their action is a complex process, as qualities quite apart from chemical purity are required. For example, the form of zinc sulphide, giving the best luminous effect on exposure to daylight, may not be that most suitable for treatment to produce continuous fluorescence.

The luminous effect induced by light in these substances is transient, diminishing greatly after a few hours in darkness. At the moment immediately after strong excitation a brightness possibly exceeding one foot-candle may be shown to exist. But in a fraction of a second this initial strong effect vanishes, and although thereafter the diminution is more gradual, a brightness below that of a white surface illuminated by moonlight is soon reached, and half an hour afterwards the luminosity is very much less still. Experimental data on the degree of luminosity attainable by strong excitation by sources rich in ultra-violet rays are needed, but the measurements involved, as Mr. Blok will show, involve great difficulties.

I am showing an experiment to illustrate phosphorescence. A cylinder coated with zinc sulphide is rotated in front of a slit, on the far side, receiving light from an arc between tungsten electrodes, which is very rich in ultra-violet light. If this cylinder is rotated at a speed of about 10,000 revolutions per minute, the side of the cylinder facing the audience becomes intensely luminous, being clearly visible, even with the lights in the room turned on. This phosphorescence is bright enough to match in brightness the illumination on a white card from a 16 c.p. electric lamp, transmitting through a green screen, only a few inches away. (Experiment.) In this way we can reproduce the intense phosphorescence which exists for a small fraction of a second after exposure, but very rapidly dies away.

The light is bright enough for the spectrum to be very clearly and easily seen through a portable spectroscope. It consists of a faint continuous spectrum with bright bands superimposed in the green.

It is difficult to account for the presence of the entire visible continuous spectrum, and it is interesting to compare this result with the spectrum obtained from self-luminous zinc sulphide excited by alpha rays. This exhibits only a band in the green at low concentrations, but a continuous spectrum is also visible with 74 mgrm. radium per gramme of zinc-sulphide—possibly the continuous spectrum is always present, but is in general too feeble to be seen, being overpowered by the preponderating green. I find the spectrum of the glow worm also gives some red and orange.

Such phosphorescent substances have found various special applications. The strongest effect is produced with the substance in a powder, but, mixed with dilute varnish, it can be applied in the form of paint.

The most important practical results have so far been obtained with the self-luminous paints, which consist of zinc sulphide with a small admixture of radio-active constituents. Radium gives off three forms of rays—alpha, beta, and gamma—the former of which is responsible for the chief excitation of luminosity. Radium itself wastes away at a rate which will reduce it to half quantity in 1,000 years. This alone, therefore, would cause an inappreciable deterioration in luminous effect. In fact, however, self-luminous paints decay at a rate varying according to their radium constituent. A diminution of 50 per cent. in brightness in the course of a year is not unusual, but much greater diminutions with a larger percentage of radium have been recorded. Half value in about 24 hours occurs with 74 mgrm. radium bromide per gramme of zinc sulphide, which strength I find to be equivalent to the light of the glowworm. On the other hand, the actual brightness, within limits, is roughly proportional to the radium content, of freshly prepared samples. It should be borne in mind that the brightness of such materials rises rapidly during two or three weeks following their preparation, reaching a maximum, and then falling continuously thereafter. This initial rise is due to the growth of radium emanation which attains a maximum in 30 days. The decay following is mainly due to destructive action of the alpha rays on the zinc sulphide.

It is therefore of very great importance to determine the order of brightness necessary for certain purposes, and not to exceed this required value, since any addition beyond this point adds to the expense and diminishes the life of the material.

There are other factors which modify the brightness of such materials. For example, I have found, particularly in the case of powder which does not completely fill the enclosure, that currents of radium emanation may exist, and the flow of this emanation from point to point within the enclosure may produce local patches of brightness and uneven distribution of luminosity. Bright patches may also be produced by local cooling, which causes local condensation of the emanation products of short period. The coloration of the glass containing vessel also affects the luminosity tests, and should be allowed for.

This discolouration is an indication of the storage of radio-active energy by ionization, and in some cases it is possible, by the action of heat, to cause the material to luminesce, releasing the radioactive energy, and thus removing the discolouration. An experiment I am performing with a piece of crystal which has been exposed to radium illustrates this. (Experiment.) You will also observe from the appearance of this piece of broken porcelain evaporating dish exhibited that the discolouration is in this case essentially a surface phenomenon, the glaze only being darkened, but with glass the colour permeates the entire solid.

Up to the present time no satisfactory means of regenerating these materials has been found, although this is possible with some substances. The diminution in brightness, as stated above, cannot be attributed to decay of the radium component, and is believed to be due mainly to deterioration of the zinc sulphide during bombardment. In cases in which the powder is enclosed in glass, the transparency of this may also be affected by the radium in course of time, and the same applies to the varnish used as a binding material when the compound is applied in the form of luminous paint.

It is to be noted that the mixture with varnish is equivalent to dilution of the radium element ; speaking generally, the brightness of material of given composition used as varnish will be about one-quarter of the value when used in the form of powder.

Such materials have many important applications in connection with the war, and the whole subject offers an opportunity for profitable research, and deserves to be more closely studied.

II.—SOME APPLICATIONS OF FLUORESCENCE AND PHOSPHORESCENCE.

By J. S. Dow.

The subject for discussion is one on which little is generally known. These phenomena, and their relation to the complex problems underlying the production of light, are of great interest to the Society. The use of luminescence in such illuminants as the flame arc, the mercury vapour lamp, and possibly the incandescent mantle, are of interest, as suggesting the possibility of more efficient light-production than can be obtained by incandescence effects ; and also because they involve free vibrations of certain wave lengths, offering the hope that eventually we may be able to control the colour of light for various purposes, as easily as we now control the intensity. The firefly has long been regarded as one of the most efficient sources of light, and researches on phosphorescent substances suggest that such forms of " cold light," though relatively feeble in intensity, have almost invariably a very high luminous efficiency. Yet the experiments on this point are a little doubtful in view of the very low luminosity, and the possibly misleading effect of the physiological complexities of the eye in such circumstances. From a scientific standpoint it would be very desirable to determine the luminous efficiency of such processes with greater precision.

The effect of such substances in the dark is also of interest in view of its bearing on the matter discussed at the last meeting—the influence of glare and contrast. The visibility of these substances depends very much on the state of adaptation of the eye. A small patch of luminous paint, particularly the blue light from phosphorescent calcium sulphide, can only be seen with difficulty by an eye recently adapted to ordinary artificial light. On the other hand, in the writer's experience, the brighter forms of self-luminous paint may, to a fully dark-adapted eye, produce an effect not unlike actual glare. It is therefore very important, as Mr. Glew has suggested, to determine the minimum brightness requisite for various purposes, and not to exceed this minimum. Another effect, also clearly in evidence with the blue light of calcium sulphide, is the " spreading " of the light at distances exceeding a few feet, owing presumably to the chromatic aberration of the eye. Again, a patch subtending a small angle of the eye appears much less bright than a relatively large area, which also tends to make the surface painted fade out of sight, and, indeed, become invisible to direct vision, at a short distance away. These effects limit the applications of such substances in their more feebly luminescent forms. Except when one can deal with relatively large areas, they are best suited to near vision. For the same reasons the photometry of a small area may not give the true effect of their use over a large surface. One becomes aware of the complexity of the problem in attempting to compare the brightness of two patches of zinc and calcium sulphide. Shortly after excitation the latter appears brightest at close quarters (a few inches away), but viewed from the other side of the room this is no longer the case. The zinc sulphide now appears the brighter. Yet at a later stage the brightness of the calcium sulphide may persist when that of the zinc sulphide has vanished.

It would seem well worth while to study the possibility of producing materials which would give a strong yellow or orange, or even red phosphorescence. The substances at present available for this purpose give but a feeble and transitory luminosity. But there seems no physical reason why phosphorescence in this region of the spectrum should not be produced in useful intensity, and the apparent low luminosity at present obtained may be due chiefly to the fact that at low illuminations the eye is comparatively insensitive to these rays.

The same applies to materials excited by radium. I should like to ask Mr. Glew if he has made any experiments with materials which would fluoresce yellow or red under the action of alpha rays. Through the courtesy of Mr. W. S. Andrews, of the General Electric Co., U.S.A., I have here a series of small discs of various materials which give a very wide range of fluorescent colour under the light from an iron spark ; I have asked Mr. Landor to exhibit this along with his other specimens. If such colours can be excited by the iron spark it is not inconceivable that similar effects might be excited by radium.

As regards the order of brightness met with, it would appear from tests by various observers on various self-luminous paints (zinc sulphide) that the following rough rule might be tentatively suggested, namely, that the actual brightness in equivalent foot candles is rather less than one-tenth of the radium content in one gramme of composition. Thus 0.4 composition (*i.e.*, material containing 0.4 milligrams to one gramme of radium bromide and zinc sulphide), yields *about* 0.04 ft.-candles, and 0.2 composition *about* 0.02 ft.-candles (*i.e.*, about the brightness of a white surface illuminated by full moonlight). For reasons already given, it is impossible to state such a rule with precision, but as a rough guide this may be useful in the case of freshly prepared material which has approached its maximum brightness. To much more powerful compositions it may not apply ; nor, of course, to materials which have undergone considerable deterioration.

The brightness of zinc sulphide or calcium sulphide a few minutes after exposure at close range to a 50 watt electric incandescent lamp (which is typical of the type of source available to the ordinary householder) is already very much less than the " moonlight " value.

From tests on some samples of the calcium sulphide "luminous buttons" the writer has found that, after the above exposure, they were practically indistinguishable to direct vision at a distance of ten feet, within an hour after exposure These buttons were about 1½ inch in diameter. The brightness in such circumstances would, therefore, not be of much help in enabling people to avoid being run over by vehicles; but they might be useful in preventing collisions of pedestrians in very dark areas, besides being an interesting novelty. On the other hand, if such material was available in large quantities for coating kerbs, lamp posts, etc., the larger area treated would alter the problem, and they might possibly have applications in places where there is practically no artificial light provided, or in enabling a party to keep in touch with one another when traversing a wood at night. The successful use of such devices seems at present to demand conditions of such low luminosity as practically excludes the use of artificial light. Otherwise a piece of white card may appear equally bright. On the other hand, little is known regarding the persistence of luminosity excited by sources very rich in ultra-violet light, such as the quartz tube mercury vapour lamp. After such exposure effects sufficiently permanent to be used for theatrical effects are said to have been produced. Luminous paint is also said to have been used for coating buoys and other marine objects, the luminosity induced by the sun's rays being reproduced during the dark hours of the night. In the absence of any artificial light this project seems more feasible, especially in the strong sunlight of the tropics. Luminescing materials have been found useful for many special purposes since the outbreak of war. If phosphorescing substances could be produced commercially on a large scale and at a cheap rate, new applications would doubtless present themselves (for example in underground passages and mines, for luminous danger-signs and other notices, &c., and for advertisments and spectacular purposes). In small quantities their successful use seems to demand frequent excitation by sources rich in ultra-violet rays. The writer has tried coating switches with calcium sulphide, but the relatively low general illumination in an ordinary interior is not as a rule enough to produce a useful effect.

On the other hand, the self-luminous materials, continuously excited by radium, have already many important special applications. The chief present limitations to their wider use are scarcity of supply and expense. It has, however, been recently calculated by a writer in the *Electrical World* that the weaker and less expensive forms of such materials could be used for coating switches at a cost of only 1d.—1½d. per switch.

III.—THE PHOTOMETRY OF LUMINESCENT SUBSTANCES.

By Arthur Blok.

The measurement of the brightness of fluorescent and phosphorescent substances is rendered difficult by two factors—(i.) the colour of the light, the spectrum of which usually consists of bands or lines situated mainly in the green or blue; and (ii.) the relatively low luminosity. Both of these factors tend to introduce the Purkinje effect. Fortunately, the chief data required are usually relative, and one can thus work throughout with a coloured screen placed in front of a comparison lamp, and designed to give a colour which more or less matches the light of the material tested. If one wishes to obtain absolute values of brightness, allowance must be made for the absorption of the screen; but the procedure for effecting this introduces all the physiological difficulties attendant on heterochromatic photometry at low illuminations. An approximate colour match may be obtained fairly easily, for example, by the use of signal green glass in testing phosphorescent zinc sulphide. but unless the spectral composition of the two lights compared is substantially identical, errors may be introduced by the order of luminosity at which the test is made, the part of the retina upon which the image is received, and perhaps, also, by the size of the photometric surface employed.

Various photometric methods have been devised for dealing with this class of substances, and in these a colour-matching screen is almost always employed. In the method described by N. E. Dorsey,* a lamp is moved back and forth behind a translucent screen forming one end of a box, and the luminous compound under test is mounted on the outer surface of the screen either in the form of paint on a card slip or in powder form in a thin-walled glass tube. Identity of colour is produced by a colour filter placed inside the box between the lamp and the screen. With this arrangement, the tested sample appears as a luminous island in a surrounding sea formed by the variably illuminated screen, and provided that a sharp line of demarcation can be obtained between the island and sea, there is much to recommend this plan. It is well known that immediate contiguity of the two luminous areas under comparison greatly facilitates the determination of photometric balance.

Mr. W. S. Andrews† uses a small lamp sliding in a tube, and having a colour screen and a plano-convex lens which gives an evenly illuminated comparison field, 1½ inches in diameter, at one end of the tube. The material under test is either painted on a glass slip or is used in powder form in a cell made by cutting a circular hole 1½ inches in diameter in paper of suitable thickness placed between glass plates. In use the two luminous discs are seen side by side slightly separated from each other.

In the method used at the National Physical Laboratory for comparing the luminosity of painted dials, a stencil replica of the dial under test is uniformly illuminated from behind by means of a glow lamp and a colour screen. The stencilled and actual dials are mounted side by side, and by means of a variable resistance the candlepower of the lamp is brought to such a value that the luminosities of the stencilled figures and those on the actual dial are the same. By an independent calibration with a surface-brightness photometer, the brightness of the stencil for any resistance setting is known. Here, the mean effect over the whole of the surfaces viewed is judged, and as long as the dials are small there should be little difficulty in doing this. But if the dials are large, the various figures will be at different distances from the eye, and it would appear that trouble may be introduced on that account. The method, however, has the advantage that by enabling finished dials to be dealt with in their entirety it gives a final comparison of their merits, whereas if small samples of paint are measured there is always the possibility that variations in the finished article may be introduced during the painting operation, for example, by irregular mixing or uneven application of the paint.

In another scheme, developed by Prof. Clinton and Mr. Dow for measuring some very small samples in association with the speaker, the sample is viewed at a constant distance from the eye through a small opening in a white screen placed at an angle of 45 degrees to the line of sight and to the axis of the photometer bench (the line of sight being normal to the bench axis). The opening is of such a size as to be completely filled by the luminous specimen fixed behind it—*i.e.*, the "island and sea" plan is adopted. The inverse square of the distance of the lamp from the screen at photometric balance is proportional to the luminosity of the sample.

A point to be borne in mind in speaking of the photometric values of self-luminescent substances is that the luminosity of the material in powder form is considerably higher than when the material is mixed with varnish or other substance to form a paint. Moreover, the thickness of the layer tested to some extent determines the foot-candle value. A further factor which may influence the result in the treatment of the substance in regard to exposure to light before the test. In the case of substances like Balmain's compound, this is obviously a matter of prime importance, but with materials depending on radio-active excitants for their luminosity, the effect of previous light action is, as far as the speaker is aware, not yet thoroughly known. Indeed, is very evident that for the systematic specification of these self-luminous substances standard test conditions still remain to be worked out, and this perhaps is another matter that might be taken up by the Society.

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* Bull. Wash. Acad. Science, Jan. 4th, 1917.

† *General Electric Review*, Oct., 1916.

Mr. Glew has mentioned the presence of a mass of radium emanation resting on the surface of a bottle of luminous zinc sulphide in such a manner as to produce a localised patch of enhanced brightness. The effect seems to deserve further investigation, and it would be of interest to know from Mr. Glew if the emanation is always located in the upper part of the containing vessel; also to know if he has any numerical data as to the ratio of the local brightness to that of the main body of the material.

For some purposes, a single photometric measurement on any of these materials may suffice, but usually it is equally important to know the rate of luminous decay with the lapse of time. It is somewhat remarkable that although the chemical and physical sides of radioactivity and phosphorescence have been brought to a very advanced stage, very little appears to have been published on the luminous values of the substances now under discussion, and one looks almost in vain for data on the practical matter of variation of foot-candle values with time for a compound of a given nature. The present activity in night operations in war has caused a very great demand for self-luminous compounds and, no doubt, the results of tests extending over moderately long periods will be available presently. Such tests require very great care, for at best the initial luminosities under measurement are small, and after some time they sink to values that are very difficult indeed to measure, at any rate by the eye, which after all is the instrument with which the substances are used in practice. The products now used commercially have brightnesses of the order of a few hundredths of a foot-candle, and give nearly monochromatic lights. These are conditions that tax the photometrist, and the repetition of observations to 5 or 6 per cent. in tests of this nature would indicate very good work.

On the whole, there seems to be a large field for the application of photometric methods in the investigation of these substances. The subject of self-luminescent materials is at the interesting stage where practical applications are emerging, and those who are conversant with the better known applications of photometry in lighting work generally might well devote attention to the investigation of the luminous phenomena exhibited by the class of bodies now being discussed.

DISCUSSION.

Mr. A. L. **Landau** said that the relegation of the word "Phosphorescence" by Stokes to express merely the after-light exhibited by certain substances after exposure to visible light or the longer of the ultra-violet rays had proved very unfortunate. Mr. Glew had told them the derivation of the word "Phosphorescence," yet the phosphorescence of phosphorus could no longer be spoken of, which was rather absurd. It must be called "luminescence," a term invented by Wiedemann to express the old-fashioned meaning of phosphorescence. Most people had never heard of the word luminescence and persisted in using the word phosphorescence, sometimes with the new meaning, sometimes with the old, and endless confusion arises. Personally he should like to see the words luminescence and fluorescence both discarded and phosphorescence restored with its old meaning and some simple word, not ending in "—escence" used to describe subsidiary phenomena. (How absurd it would be to call the magnetism of soft iron, while it was an electromagnet, "fagnetism" and to call only its permanent magnetism "magnetism." Yet it was just this absurdity that had occurred in connection with phosphorescence!)

Certainly it was sometimes of practical importance that a substance should exhibit no after-light, for instance in the case of X-Ray screens, but at other times the value of substances depended on this very quality of giving an after-effect, e.g., in the case of luminous paints. Scientifically it was also of importance to notice whether or no after-light occurred and try to find out why this should be; but these were subsidiary phenomena.

As an illustration he was showing some manganiferous zinc sulphide exhibiting no after-light, and also some chemically identical material, exhibiting much after-light. He could make a whole series between the two, and do the same thing with dozens of other materials, e.g., with other varieties of zinc sulphide, artificial silicates, tungstates, sulphates, phosphates, etc. The same point could be demonstrated by merely varying the temperature. After-light, in short, was a matter of subsidiary importance and it was absurd that the word phosphorescence, which was formerly used to embrace essential phenomena, should be relegated to denote what is merely a sub-sidiary operation. However the word luminescence had now been generally substituted, and one must bow to authority in this matter.

As Mr. Glew had explained, Luminescence is applied to the emission of light from a comparatively cold source ; hence the term "cold light." But one should not leave out of account possible cases of luminescence accompanying incandescence. The incandescent mantle was a case in point. It owed its brilliancy to selective radiation, and its light was not due purely to incandescence. It emitted but little ultra-violet light as compared with green, but was not nearly so hot as it looked. This was really a case of "Thermion-luminescence." This should not be confused with "Thermo-luminescence," the light emission which took place when certain substances were warmed after having been exposed to light or some other excitant. As an example of the latter effect he was exhibiting some powder which had been exposed to light 24 hours previously. It was barely possible to detect any luminosity now, but when the powder was dusted over a warm plate it sparkled brilliantly. (Experiment.)

It was not likely that thermo-luminescence would be commercially important, but thermion-luminescence undoubtedly would become, more and more, the rival of pure incandescence; inexpensive luminescence was dependent on "torrents of ions" being available.

Burning magnesium owed its brilliancy and actinic powers chiefly to thermion-luminescence and the flame was not nearly so hot as its ultra-violet character would suggest.

He was now going to show some experiments illustrating luminescence in various colours under the action of a spark between iron electrodes, which was very rich in ultra-violet light. He was indebted to Dr. Walmsley, Principal of the Northampton Institute for the loan of the ultra-violet apparatus, and to Mr. W. S. Andrews of the General Electric Co. (Schenectady, New York) for a number of sketches of flowers and other objects executed in luminescing materials and giving the most artistic colour-effects under the influence of ultra-violet rays. Among these was a representation of a church window, which had nothing special in its appearance by ordinary light, but when excited by ultra-violet rays showed the most beautiful blending of colours. The series of discs of different materials, also prepared by Mr. Andrews, to which Mr. Dow had referred, served to show the variety of colours that could be produced in this way. (Experiment.)

An interesting possible application of this phenomenon was illustrated in the next experiment. He had two ordinary ten shilling notes, one of which had been partially coated with certain luminescing materials. By ordinary light both appeared identical, but under the ultra-violet rays the coated note showed white and green luminescence. This method might be applied to guard against the forging of bank notes and cheques. A private mark could easily be made on a genuine cheque or document and the cashier, by utilising an exposure to ultra-violet light could determine in a moment if it were genuine. Suitable substances could be obtained which it would take years of research to imitate, but which, if incorporated in a bank note, would not be noticeable by ordinary light but immediately revealed in ultra-violet light.

The specimen of manganiferous zinc sulphide which he exhibited was a good example of tribo-luminescence. Willemite, manganiferous zinc silicate, under powerful mechanical treatment was exceedingly brilliant. Neither of the substances shown was crystalline, so there was not much truth in the text-book statement that tribo-luminescence was caused by the rupture of crystals.

In the Moore vacuum tube a form of lighting luminescence had been used on a practical scale for lighting. There was formerly an example of this form of lighting at the escalator in Liverpool Street station. Such tubes were only suitable for general lighting when of considerable length. Mr. W. S. Andrews had proposed to increase their afficiency by placing in them aluminium sheets coated with such substances as zinc sulphide and willemite. He exhibited a model of such a tube.

Over a century ago it was discovered that the Toricellian vacuum in a mercury barometer became luminescent if the barometer was moved. Some mercury tubes he was now going to show were the outcome of this old observation. The one first exhibited utilised a partial vacuum containing neon and also willemite. The best result of all was obtained from willemite in a partial air-vacuum, but he had unfortunately broken the only tube of this kind that he had possessed. The idea of using the noble gases, and also the conception of using willemite was due to Mr. Andrews, who had presented him with the "shaker tubes" he had exhibited. The preparation of the materials used therein required some care; he understood from Mr. Andrews that of all specimens of willemite, natural and artificial, which he had used only the variety made by the firm with which he (Mr. Landau) was associated was suitable for use in these tubes, and he had found no other solids of any kind that luminesced therein. He was inclined to think that such tubes, if methodically developed, might have some useful practical applications.

As regards Mr. Dow's remarks on the duration of the luminosity from luminous paint, I have previously pointed out that in a town like London there is a faint glow even on the darkest night and that the reflection of this glow from a piece of white paper is as bright as luminous paint two hours after exposure to a source of light. It is therefore desirable that such materials should be exposed for a few seconds every two hours, or more frequently. There is no trouble in re-exposing a luminous badge and large fixed surfaces may be reactivitated by a portable actinic light. In out-of-the-way places where there is no appreciable reflection from white paper, luminous paint, even without frequent exposure, is quite useful, as has been found in many instances since the outbreak of war.

Apart from such useful effects, however, buttons, flowers and the like are of service as "scientific toys" that bring home to the general public the existence of these curious phosphorescent phenomena and stimulate interest in a subject of considerable importance.

Mr. C. C. PATERSON said there were many points in Mr. Glew's paper one would like to discuss. While at the moment it was not possible to enter into many details of the subject he would like to refer to one or two points. For the past eighteen months they had been actively engaged in investigating the luminosity and rate of decay of luminous compounds mainly in connection with work for the Admiralty, and the results which would shortly be available would, he thought, be satisfactory from the point of view of the life and luminosity of materials after long periods. An important point to remember, however, is that when in powder form before application to dials, radium luminous compound, after a rapid initial rise, commences to fall in luminosity at the rate of between 4% and 5% per week. The rough rule, therefore which Mr. Dow had suggested would apply fairly well when the material was at its maximum luminosity but naturally would not do so when it was two or three months old and the brightness had deteriorated by a variable amount according to the nature of the composition

The ordinary standard paint used for dials when kept in powder form, falls to half its value in about six months. A considerable amount of material used for special war purposes, which is not mixed with varnish, might be in store for this period. One must, therefore not set too high a standard in the expectations formed of the brightness of such materials at the beginning of their useful life. As Mr. Glew points out, the rate of decay of the compound is considerably less when mixed with varnish and painted on dials.

The apparatus he had brought to the meeting was not the actual apparatus used for testing dials, as this was too bulky for convenient exhibition, but would serve to show the principle which had been evolved by himself and Mr. Walsh for measuring the luminosity of dials. The painted dial to be tested was compared with two similar stencilled dials, figures of equal dimensions being cut out of metal sheets. Behind these stencilled artificial dials was a translucent surface illuminated by the light from a metal filament lamp, passing through a sheet of suitable green glass so as to give a colour match with the luminous paint on the dial tested. The brightness of the background is calibrated in candles per sq. millimetre according to the voltage on the lamp illuminating it, and one then knows what is the brightness of the stencilled figures placed in front of it. The luminosity of the background can then be adjusted by altering the current through the electric lamps until the figures on the artificial dials and the dial under test appear equally bright.

In the first apparatus made they had used one single artificial dial, but it was found that the relative positions of the single artificial and the test dials affected the result of test and better results had been obtained by using two artificial dials, one on either side of the dial tested. When, in the first arrangement, the two dials were arranged one above the other, it was found that most people tended to assign a higher value to the lower dial than the upper one; on the other hand, when the dials were placed side by side some people favoured the dial on the right and some the dial on the left; they seldom got the same value. By using two stencilled dials, one on either side of the dial to be tested one got an impartial result. They found it best to look slightly above the dials and judge, not by direct but by slightly peripheral vision, looking alternately at the dials. In this way one might expect to repeat single readings to within 10 per cent. and the mean of five readings to about 5 per cent.

He had been very much interested to see the sketch Mr. Blok had drawn of the photometer involving a small aperture in the photometric screen behind which was placed the material to be tested. This apparatus was practically identical with one they had been using at the National Physical Laboratory. It was interesting to see how, in dealing with these problems, other people had been led to adopt the same methods. This was quite a satisfactory method, much better than the device of placing the luminous compound in front of the photometric surface.

He did not agree with Mr. Blok that the Purkinje effect need seriously affect the accuracy of absolute determinations of surface brightness of luminous compound. This would be the case if the coefficient of transmission of the green filter were determined at a high illumination and applied to the case of the low illlumination, but if this determination were made by a number of observers at approximately the equivalent illumination of the paint itself, the result should be a true absolute value in terms of the average of those observers. In their own measurements they had used a sample of luminous compound as a comparison source for the determination by the substitution method.

The CHAIRMAN (Mr. F. J. Cheshire), after inviting further contributions to the discussion, moved a cordial vote of thanks to Mr. Glew for opening the discussion; they were greatly indebted to Mr. Glew and the other gentlemen who had arranged demonstrations for an interesting evening.

The subject was one of considerable importance at the present moment. Mr. Paterson had rightly emphasized the importance of the rapid falling-off in luminosity which takes place in a freshly prepared mixture of radium and zinc sulphide. Generally speaking such mixtures would not come into actual use for some considerable time after being prepared so that the light emitted during this period was for all practical purposes lost. If Mr. Glew could only give to one of his magical tubes a small dose of something which would place the radium mixture in a condition of suspended animation the difficulty would be met. The ideal mixture, of course, would be one that suddenly attained its maximum brightness in, say, two months' time and maintained it to the end of its life. At the present time, however, the greatest luminosity was attained at a period when it was not required.

Another important problem was the discovery of recuperating the zinc sulphide after it had been exposed to prolonged bombardment by the radium. If, for example, we could submit a mixture of zinc sulphide and radium in which the zinc sulphide had been bombarded to extinction, to powerful ultra violet light or some other excitant which would restore its original luminous power this would be a most valuable result.

At the present time the activities of scientific societies interested in such subjects were naturally concentrated mainly on utilitarian results. But in doing so they often became aware of new problems requiring investigation and it was most important that all such matters should be kept on record for future investigation when they were free to devote themselves more fully to the more academic lines of research.

Since the outbreak of war the services of the scientific societies had been of very great value in dealing with urgent problems. The particular problem under discussion was one that required much wider study and he was very glad to see that it was being brought to the notice of the members of the Illuminating Engineering Society.

The Hon. SECRETARY (Mr. L. Gaster) proposed a vote of thanks to the Chairman for presiding at the meeting, in spite of the many urgent calls upon his time. He also wished to emphasise the Society's indebtedness to Mr. Glew and the other gentlemen for the interesting demonstrations provided.

The subject was one of very great interest to the Society, and the presence of Mr. Cheshire in the Chair was an indication of the importance which was to be attached to many of these phosphorescent and fluorescent effects for war purposes.

His attention had been drawn to these phenomena on the occasion of a visit to the United States, now ten years ago, when he had an opportunity of seeing the collection of luminescing materials of Mr. W. J. Hammer in New York, and of witnessing some striking pictorial effects in various colours under the action of the ultra-violet rays.

Apart from its scientific importance, phosphorescence might have many important applications in the future. Already, in connection with his work on the Safety First Council, his attention had been called to the possibility of using luminescing materials in the form of armlets, or for painting kerbs, lamp posts, etc., so that they could be seen in the dark.

It was most important for them to be able to form some idea of the reliability of luminescing materials for such purposes and it would be most useful if a series of tests could be undertaken in order to ascertain the order of brightness that was requisite to give a useful effect, and the suitability in practice of the substances at present available.

Mr. F. HARRISON GLEW, in reply, expressed his appreciation of the kind way in which the vote of thanks proposed by the Chairman to himself and the others who had arranged demonstrations had been received. The Society was to be congratulated on the interest they were taking in these problems, which were of national importance, and he would like to add that the attention devoted to the subject by the Chairman had been an element of very great consequence in furthering research in this fascinating field of study. As the Chairman remarked, they were now all primarily engaged in the study of the practical application of the materials already available. But he felt quite sure that after the war the matter would not be allowed to drop, and would be the subject of much more research than was possible at present. Taking a broad view, it would be found that the phenomena they had to study in connection with fluorescence and phosphorescence had a vital bearing on the fundamental problems connected with the production of light. They were therefore essentially such as should receive attention at the hands of the Illuminating Engineering Society.

Added :—

With reference to the point raised by Mr. Dow as to the behaviour of substances giving yellow or red luminescence, I have examined the varieties of phosphorescent zinc sulphide, yielding yellow and red light, both of which, however, gave very disappointing results when mixed with radium, although the response to light is good. The green variety is by far the most effective with radium. Samples giving the most persistent phosphorescence with light are not always the most suitable under Alpha radiation. Structure, apart from composition, plays an important part, for if the crystals are ground to powder there is very little response to any kind of rays.

As regards Mr. Blok's question about the very bright patches which I have noticed in a closed vessel containing radium compound, in one instance on measurement I found the patch to be over four times brighter than the general surface luminosity; I have observed much brighter effects. I have never seen this effect anywhere else than on the upper surface of the powder. This interesting effect is still being investigated; it is due to circulation currents of the gaseous radium emanation mixed with air. This emanation is continually changing with radium "A," which is a solid, remaining where deposited by the convection currents of air. This solid deposit of Radium "A" would in itself give increased brightness because each atom of it gives off another Alpha particle then becoming Radium "B," which again in its turn changes into Radium "C," which gives further Alpha particles, also Gamma rays—still further increasing the luminosity locally, first determined by the "A" deposit. The time period required for the rise and decay of these luminous spots coincides with the equilibrium periods of "A," "B," and "C." In the Journal of Röntgen Society I have shown that Radium "A" is deposited by a relative difference of temperature of only a few degrees. The practical point is that these extra bright patches must mean a reduction of luminosity elsewhere in the mass of compound which is therefore variable in brightness.

As the Chairman had pointed out, it was highly desirable to temporarily suspend the activity of these compounds until actually required for use—unfortunately the physicist is at present powerless to alter the rate of change of radio-active substances; a system of cold storage would be a great economy, especially for the dry powder form, but a certain amount of reserve action might be obtained by mixing the powder with the varnish in cases where it would be used as paint before sending to distant countries, as the varnish would cut down the activity to about one-fourth, preventing initial wasteful action on the zinc sulphide.

The alternative problem of recuperation of spent zinc sulphide is fascinating and important. I will give ultra violet light a trial as suggested; however, daylight has not the desired effect. I tried this on one occasion by exposing to daylight one-half of a flat tube, five inches long, of old spent radium compound. The exposure lasted a few weeks. The result was a very slight increase in luminosity, but close examination revealed the fact that this was due to discoloration of glass, not to revival of the zinc sulphide. Fortunately zinc sulphide is not damaged by daylight, one specimen test surface, half of which was exposed to daylight, including direct sunlight, continuously for over two years, does not indicate any deterioration on comparison with the covered half. On the other hand each Alpha particle is a projectile, absolutely destructive, producing 90,000 ions. I have demonstrated elsewhere* that solids so exposed may be in a condition of mechanical stress, as indicated by the buckling and bending of mica; the crystals are probably similarly strained to disruption.

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* Journal of the Röntgen Society, No. 44 Vol. XI., 1915.

An Improved Form of Phosphoroscope.

In the *General Electric Review* for March, 1917, Mr. W. S. Andrews describes an apparatus enabling excitation by ultra-violet rays to be applied to any substance at rapidly recurring intervals, the resulting phosphorescence being observed in the intermediate intervals of darkness. The substance to be examined is placed in a light-proof case and a rotating shutter driven by an electric motor. The material is exposed, and then the ultra-violet rays shut off, about 3,000 times a minute. The eye thus sees a continuous phosphorescent effect.

CORRESPONDENCE.

THE LUMEN AS A MEASURE OF ILLUMINATING POWER

Sir,—I have read with much interest the discussion on "The Lumen as a Measure of Illuminating Power" in the January issue of *The Illuminating Engineer.* It seems strange to read this discussion in 1917 when we, over here, have become so accustomed to the "Lumen" and to "Lumens per watt" that we have almost forgotten that a lamp has a candlepower rating.

"Candle Power," surely, is merely a rating and not a measure of luminous intensity. A "16 c.p." lamp is a 16 c.p. lamp whether it is burning or not just as a 250 h.p. engine (rating) is a 250 h.p. engine whether it is delivering energy or not. And just as the latter rating for an engine means little unless the other characteristics (efficiency, overload, capacity, etc.) are stated, so the candlepower rating of a lamp means nothing unless the energy radiation, the visible quality of this radiation measured as luminous flux, the luminous efficiency, etc., are also given. Obviously the most important things to know about any lamp are *first* its luminous flux, and *second* the distribution of this flux, as determined from its polar curve of "apparent candles" (not candle power) or directly by its polar curve of flux density.

The point I wish to make, however, is that *the phenomena dealt with in illuminating engineering are psychological and not physical.* Luminous flux in space is merely imaginary. Light from the view point of illumination does not exist except in the brain, and then only as the sensations of brightness and colour. Leaving colour out of our discussion, we may say that *the eye sees brightness.* Brightness should, therefore, be our starting point.

In one of his papers some years ago Dr. H. E. Ives said that "the art of lighting is the art of the proper distribution of brightness." This is the crux of the whole question. We begin with brightness and all other terms are merely convenient ways of expressing it. If the projected area of the source of light is one square centimetre, and the flux of light therefrom is one Lumen then we say that the intensity of the brightness sensation caused by looking at the source is one lambert. This if b_0 be the intensity of the brightness sensation, S the area of a field or image, the total visible effect is $b_0S = L$, and this is called "Lumens."

But whether we express this luminous effect in terms of lumens, candles, footcandles, etc., we are always dealing with the same thing.

The illuminating engineer is more than a computer of "Lumens." He must also be a psychologist. It is his business to enable people to see properly, comfortably and pleasantly. Having decided how an interior should *look* he must next decide how the incident "luminous" flux must be distributed to produce the desired effect, and then consider the appropriate lighting equipment.

The study of brightness leads us at once to a study, from the view point of illumination, of the multiplicity of materials that may constitute the field of view. We must familiarise ourselves with the reflecting and diffusing qualities of the materials of construction and decoration—paints, papers, glass, both painted and dyed, woven materials, &c. Glare, contrast, and colour here enter the problem, so that it becomes very complicated. Indeed, the computation of lumens is child's play compared with the preliminary brightness studies.

I trust I have made it clear that the Lumen is a measure of the possibility of visual sensation and is not a measure of physical flux. I emphasise this, not because there is anything inherently wrong in treating luminous flux, by courtesy, as a real flux; but because so many seem to have drifted unconsciously from this into thinking of the visible effect of radiant energy as a real flux in space and thus engendering the wrong view point of illumination.

Yours, etc.,

BASSETT JONES.

[Owing to restrictions of space, this letter has been somewhat abbreviated.—ED.]

SHORT NOTES
ON
ILLUMINATING ENGINEERING.

ILLUMINATING ENGINEERING SOCIETY, U.S.A.

Offer of Services to the Government.

WE observe in the Transactions of the Illuminating Engineering Society, U.S.A., for March 20th, a note of the following resolution, which was made effective early in 1917 :—

"Resolved that in the present exigency the Council of the Illuminating Engineering Society offer to the United States Government for the purpose of national defence every assistance within the scope of illuminating engineering which the Society can contribute, and that the General Secretary be and hereby is instructed to transmit this resolution to the Secretary of War, the Secretary of the Navy, and to the Chairman of the Naval Consulting Bureau."

Letters of acknowledgment, thanking the Society for its offer of services, have been received from these three departments. We are glad to see that the Society in the United States, like our own Society, has promptly placed its services at the Government's disposal, and we do not doubt that it will be able to render substantial assistance in many ways.

In this country experience has fully confirmed the necessity of expert advice from the leading professional, scientific, and technical institutions being freely rendered to the authorities, and we may be sure that the United States Government will be quick to recognise the value of the services which scientists and engineers can render to the common cause.

WORKSHOP METHODS OF OPTICAL TESTING.

An interesting and well attended exhibition of Workshop Methods of Optical Testing was arranged by the Optical Society at King's College, Strand, on the evening of Thursday, January 11th. The exhibition was very well attended. Among the exhibits we noted an instrument for the accurate determination of various elements in screw threads by the Cambridge Scientific Instrument Co., and a wave-plate for the rapid assessment of the double refraction existing in glass by Messrs. Chance Bros., Ltd. ; and some devices for testing the curvature of test plates, by Mr. S. D. Chalmers. Dr. R. S. Clay showed a series of instruments for determining the refractive index of liquids and transparent solids, and for measuring the angle between the optic axes and the magnifying power of binoculars.

There was also quite an extensive series of exhibits by the Optical Department of the Ministry of Munitions, which included methods of testing telescopes, sights for rifles, binoculars, &c. The "incandescent arc" (Pointolite) lamp of the Edison and United Electric Co., Ltd., which is specially adapted to optical work, was on view. A development in these lamps is the production of small size units for galvanometer work.

One particularly interesting item was a method of testing dials painted with radium luminous paint, which was shown in an adjacent dark room by the National Physical Laboratory. The luminous dials are compared with stencil plates having figures of similar size. These plates are illuminated from behind by an incandescent lamp screened with green glass so as to produce a colour match. The brightness of the "artificial dials," one of which is arranged on either side of the dial to be tested, is adjusted by altering the current supplied to the standard electric incandescent lamp.

TERMINOLOGY IN A LIGHTING CASE.

A case that occurred within the last few months in Edinburgh, reported in the *Gas World*, illustrates the confusion which may be caused by the varied interpretation of such phrases as "minimum intensity" in lighting regulations.

We reproduce from our contemporary the account of the proceedings :—

Before Sheriff Guy, in the Edinburgh Sheriff Court on the 28th ult., a solicitor, Mr. C. George, was charged with failing to reduce his house lights to the minimum intensity.

Mr. George contended that the complaint ought to specify what was the effect from the outside of his alleged failing to screen his lights, whether there was more than a dull, subdued light visible, or whether any part of the pavement, roadway, building, or any other object, was distinctly illuminated. The complaint was irrelevantly stated, and the expression, "did fail to reduce to the minimum intensity," was not justified by the lighting order.

Sheriff Guy said the meaning of the expression "minimum intensity" was "the weakest strength," but Mr. George said he was in a fog as to the meaning of the expression. Under the order he was entitled to a maximum strength, which was a dull, subdued light. He was not tied down to "minimum intensity," which, he had been told, was absolute darkness.

Sheriff Guy : With gas it would be a "peep."

Mr. George : Yes, but electric light can only be shaded.

Sheriff Guy : This is the first time I have heard this point of relevancy raised. Hundreds have pleaded guilty to this charge. They seem to have understood it.

The procurator-fiscal contended that he had followed out pretty closely the wording of the order.

Sheriff Guy : "Minimum intensity," whatever it means, is not implied by the order. So far as I read the order, you may have the biggest blaze of light inside so long as you keep it inside.

The Sheriff gave his decision the following day. He allowed the procurator-fiscal to delete the phrase "minimum intensity," as it had evidently been taken from another section of the statutory rules and orders issued in regard to outside lighting. The object of the prosecutor his lordship said, was to impose a penalty upon persons who let too much light out of their houses at night. A further objection to the complaint was that there had not been sufficient specification, that the room of the house where the alleged light was showing was not stated. The meaning of the section was that persons who let too much light out of their houses paid the penalty. There was sufficient specification. They must keep these complaints in workable order, because it would be difficult to specify the particular window of a house. There was no prejudice caused to anyone by not stating the exact room.

LIGHTING RESTRICTIONS IN GERMANY.

It appears that strict precautions were recently ordered to be adopted by the military authorities in respect of all towns in the Grand Duchy of Baden in order to minimise the dangers arising from raids by enemy aviators. The regulations forbid all exterior lighting and all interior light in houses, shops and restaurants, and factories must be carefully hidden by curtains.

When the alarm signals are sounded the people must immediately leave the streets and take refuge in the nearest houses, the occupants of which are obliged to open their doors to them. It is strictly forbidden for people to assemble in the streets or open places. The new regulations came into force on October 1st, 1916.

LUMINOUS PAINT FOR SWITCHES.

According to the *Electrical World* luminous paint of the so-called "permanent" variety is finding a useful application for coating switches, so as to enable them to be easily distinguished in the dark. It is proposed to coast press-buttons with a small amount of the paint, or to tip the screws attaching a switch to the wall. The cost of making and applying the paint for this purpose, which will contain only a relatively small percentage of radium bromide, works out to about four shillings per square inch. The extra cost of equipping a switch with sufficient paint should not, therefore, exceed about 1d. or 1½d. In view of the small amount of radio-active material mixed with the zinc sulphide the deterioration of this paint will only be very slow, and the useful life is estimated at 10—15 years.

For certain highly specialised purposes paints having a much larger proportion of the radio-active element are employed and in this case the brightness of the paint is naturally very much greater. The greater brilliancy, however, is only attained at the expense of useful life, as the bombardment of the zinc sulphide by the alpha-rays emitted by the radium bromide causes more or less rapid deterioration.

GAS LIGHTING IN A CATHEDRAL.

Calculations on a Lumen-Basis.

In this journal some particulars were given in 1916 of the interesting semi-indirect gas installation in the Cathedral of St. Peter and St. Paul in Philadelphia. Some additional information regarding the preliminary calculations of illumination were given by Mr. J. D. Lee in the *Transactions of the Illuminating Engineering Society* (U.S.A.) for October 1916.

It was assumed that with this form of lighting the utilisation efficiency would be about 25 per cent., *i.e.*, that only 25 per cent. of the light derived from the lamps would be received on the working plane.

The total lumens is therefore given by the formula :—

$$\frac{\text{Illumination} \times \text{Floor Area}}{0{\cdot}25}$$

In this case an intensity of illumination of one foot-candle was considered sufficient and the area to be lighted is approximately 150 ft.—200 ft. The total lumens required are therefore :—

$$\frac{150 \times 200 \times 1}{0{\cdot}25} = 104{,}000 \text{ lumens.}$$

The incandescent units of the types selected were previously found to give approximately 315 lumens per cub. ft. The consumption of gas required to light the floor area is thus equal to :—

$$\frac{104{,}000}{315} = 318 \text{ cub. ft. per hr. approx.}$$

Each burner of the type decided upon consumes 2·75 cub. ft. per hour., so that the total number of mantles needed would be about :—

$$\frac{318}{2{\cdot}75} = 115 \text{ approx.}$$

It was decided to use twelve appropriately spaced units so that each unit would have, on the average, 10 mantles. After various experiments, the final arrangement comprised twelve units, six with fifteen mantles, and six with twelve mantles. The correct spacing would depend on the distribution of light from the units, and was also worked out beforehand

A NEW SYSTEM OF CHURCH LIGHTING.

A recent issue of the *Electrical Review and Western Electrician* contains an account of a highly novel form of lighting used in St. Adalbert's Church in Chicago and subsequently applied to other churches of the basilica type. The application of modern illuminants to such churches has been a difficult problem. If they are installed on huge chandeliers of the type used in by-gone days, when only candles and oil lamps were available, the effect is apt to be incongruous and glaring ; the chandeliers are difficult of access, making renewals of lamps a troublesome matter.

A system of studded lights in the ornaments of the columns and on the ceiling has been tried, but the method is open to the objections of glare, inefficiency, and difficulty of access. Purely indirect lighting is unsatisfactory for very high ceilings.

In this case the problem has been met by a combination of direct and indirect lighting, the lamps being arranged in aspecially designed moulded cornice running, on either side, the entire length of the church. The cornice is hollow and the direct lighting is afforded by lamps in appropriate reflectors mounted in the under side. Above special units throw addtional light on the ceiling and show off its ornamental nature. All the lights are out of the range of vision and easily accessible from a chamber running the length of the church immediately behind the moulding.

LIGHTING THE DOME OF ST. PAUL'S.

A correspondent writes to mention that in the *Leisure Hour* for 1872 he has discovered a suggestion, under the heading "Public Illumination," that the dome of St. Paul's should be illuminated by electric light impinging upon it from concealed sources in various directions.

This is one instance of the common experience of finding in old books and magazines ideas much ahead of their time. Another case is furnished by the *Œuvres de Lavoisier*, in which quite a comprehensive study of the design of reflectors is to be found.

As our correspondent remarks, the writer of the above article has surely a good claim to be considered one of the pioneers of "flood lighting."

FLOOD LIGHTING AS AN AID TO TRAFFIC.

The dark conditions in our streets have recently emphasised the need for some method of identifying policemen engaged in the guidance of traffic. We note that in St. Louis, where the illumination is presumably "normal," another novel device is being tried at certain important street intersections. In dark and foggy weather officers on duty have sometimes been struck by passing automobiles and various devices have been tried to render them more visible.

The latest method is to illuminate them by a searchlight beam, proceeding from a half-watt lamp with focusing reflector, which is mounted on the second or third story of a building in the vicinity. This lamp throws a strong local light on the officer, and, to increase his visibility still further, he is equipped with white gauntlets. The method is said to have given great satisfaction.

ILLUMINATING THE STATUE OF LIBERTY.

We have often drawn attention to the value of concealed lighting as a means of making statutes and memorials visible by night as well as by day. In the United States the "flood lighting" of such memorials has made great strides since the introduction of the gas-filled lamp, one of the most noteworthy examples being the illumination of the gigantic Statue of Liberty at New York Harbour, always one of the first objects to catch the eye of the visitor entering this port by day.

The illumination is achieved by two hundred and fifty 250-watt lamps installed in fifteen banks of projectors. The surface brightness of the statute is given in the *Electrical World* as about 10 ft.-candles, and it is estimated that the statue itself thus becomes a source equivalent to about 6,000 candles. In addition the flaming torch carried by the figure yields about 4000—5,000 candles, and this alone contains in its glass structure fifteen 500-watt lamps, specially arranged to give even illumination.

We understand that the cost of illuminating the statute was defrayed by public subscription, and President Wilson presided when it was first lighted up. The illumination of the statute in fact may be regarded as a public recognition of the possibilities of such spectacular lighting, and we hope that, when times of peace return, the significance of the step will not be lost on public bodies in this country.

EFFECTS OF BRIGHTNESS AND CONTRAST IN VISION.*

BY P. G. NUTTING.

DR. KERR, in his recent paper before the Illuminating Engineering Society, mentioned the need for more definite data on glare. Some experiments made by Mr. P. G. Nutting on this point are of interest.

The chief factors of importance, as regards the effect of contrast on vision, are :—(1) *photometric sensibility*, the brightness just noticeable in adjacent fields ; (2) *threshold sensibility*, the lowest perceptible brightness ; and (3) *glare sensibility*, the brightness which is just painfully bright. All these factors vary greatly with the general illumination. An eye adapted to a very low illumination can perceive a much lower brightness than an eye recently exposed to relatively bright conditions, but at a low illumination the percentage brightness detectable is much smaller. Also, as common experience suggests, a relatively mild luminosity may be dazzling to the dark, adapted eye, whereas in full sunlight quite a high value may be endured without discomfort. These relations are expressed numerically in terms of the three factors noted above.

The results were obtained as follows : The eye was sensitised in each case to a certain brightness by viewing a white field illuminated to the proper amount. This field was 60 cm. square, and viewed from a distance of 35 cm., and was illuminated to intensities ranging from 0·000001 millilamberts to 2,000 millilamberts. After sensitising, the light was switched off, and an attempt made to see a small square (30 mm. square) in the centre of the large square field, illuminated from behind. The brightness of this small square was adjusted until it could just be seen at the instant of switching off the brighter field. This "instantaneous threshold" gives a measure of the sensibility of the retina when adapted to the brightness of the sensitising field.

In obtaining the glare data a similar procedure was followed, except that in this case the brightness of the central patch was increased until it just appeared uncomfortably bright with the eye adapted to the given brightness of the surrounding field.

(Presumably, in obtaining the "Difference Fraction" representing the change in brightness just detectable, all that was necessary was to alter the brightness of the central square until it could just be distinguished from the larger area, when the latter was illuminated to a given amount.)

The following table shows the results obtained. Brightness is expressed in millilamberts (ml.) or lamberts (l.). It is convenient to remember that a millilambert is roughly equal to a surface brightness of one foot-candle.

VISUAL SENSITOMETRIC DATA.

Field Brightness.	Difference Fraction.	Discrimination Factor.	Threshold Limit.	Glare Limit.
ml.			ml.	ml.
0·000001	(1·00)	1·0	0·00000093	20·1
0·00001	(0·66)	1·5	0·0000042	40·7
0·0001	0·395	2·5	0·000019	89·0
0·001	0·204	4·5	0·000087	186·0
0·01	0·078	12·8	0·00039	400·0
0·1	0·037	27·0	0·00174	810·0
				l.
1·0	0·0208	48·2	0·0081	1·66
10·0	0·0174	57·5	0·036	3·42
100·0	0·0172	58·1	0·28	7·25
1000·0	0·0240	41·7	2·15	14·45
10000·0	(0·048)	(20·9)	(232·0)	30·90

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* Trans. I.E.S. (U.S.A.), Dec. 30th, 1916.

The "Discrimination Factor" (B/dB) is the reciprocal of the Difference Fraction of brightness perceptible, and is thus a convenient measure of the photometric sensibility. It reaches a maximum of rather less than 2 per cent., about 10—100 millilamberts, decreases rapidly when the brightness falls much below 1 millilambert, and also decreases above 100 millilamberts, owing to glare. The "threshold limit," as might be expected, shows enormous variations, according to the brightness to which the eye is adapted. Thus an eye dazzled by exposure to 1,000 millilamberts can only perceive as light about 2 millilamberts, but an eye adapted to the low brightness of 0·000001 millilamberts can perceive about 0·0000009 millilamberts.

For determining the order of brightness which will just cause glare, Mr. Nutting gives the useful relation, $G = 1700 B^{0.32}$, G being the glare value and B the brightness to which the eye is adapted.

An examination of columns (1) and (5) in the table shows that at 10 millilamberts (about the brightness usual on the working area in a strongly artificially lighted room), the glare limit is 3,470 millilamberts. The glare-ratio is thus 347. At 100 millilamberts, similarly, the glare-limit becomes 72·5.

These figures thus give some support to the suggestion that *the ratio of brightness met with in ordinary interiors should preferably not exceed* 100 : 1, but this ratio may safely be exceeded considerably at very low illuminations. At a brightness of 52 lamberts, which is about four times as bright as white paper illuminated by direct sunlight, the field itself appears glaring, even with bright surroundings, and we have reached the condition of "absolute glare" (this is a brightness equivalent to about 12 c.p. per sq. in.).

LIGHTING AT THE MERSEY DOCKS.

A correspondent of the *Liverpool Journal of Commerce* recently drew attention to the need for better illumination in the Mersey Docks. "If there is one thing more than another that the modern captains of industry are agreed upon," he says, "it is that it is economically sound to have as much light and space as is possible in which labour operations are to be carried on." Yet it appears that the conditions of lighting in the docks are often unsatisfactory. The lights are fixed, and not movable, and there are not switches for individual lamps, with the result that all must be turned on when work is in progress. Even so, light is frequently shown at points where it is not wanted, leaving adjacent regions in semi-darkness.

A frequent bone of contention between shipowners and their master porters is the payment for light in the winter months, between the hours of 7—8 a.m. and between 4 and 5 p.m. In this connection the correspondent remarks: "It certainly does seem to me only right that as the Board provide the sheds they should also provide the lights to work in them during ordinary working hours."

ILLUMINATION OF THE NIAGAR FALLS.

One of the latest applications of "flood lighting" in the United States is the illumination of the Niagara Falls by concealed gas-filled incandescent lamps in concentrating reflectors. One hundred such lamps, each credited with and equivalent candlepower of about 500,000, are used. The shelters in which the lamps are placed will, in course of time, be completely covered with ivy and moss, thus forming an entirely inconspicuous feature in the landscape.

HEADLIGHTS ON LOCOMOTIVES IN THE UNITED STATES.

We notice that, according to *Popular Mechanics*, the Interstate Railway Commission in the United States has ordered that all railway locomotives shall be equipped with headlights which will be strong enough to enable a person in the engine cab to see a dark object the size of a man at a distance of 1000 feet from the engine.

This decision has been taken as a result of an investigation lasting several years.

TOPICAL AND INDUSTRIAL SECTION.

[At the request of many of our readers we have extended the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]

THE HOLOPHANE ILLUMINATION CALCULATOR.

We have before us an interesting little device for illumination calculations, produced by Holophane, Ltd. It consists of a three-page, stiff-backed booklet, which can be easily slipped in the pocket. The centre page carries the calculating device, the two pages on either side being devoted to explanatory data and tables.

It is somewhat difficult to explain the nature of the calculator in a brief space. But it consists essentially of two discs, fitting one above the other and capable of rotation, the upper one having appropriate slots at top and bottom which fall respectively above scales denoting area lighted and heights of reflectors. In using the apparatus the operator must first decide whether direct, semi-indirect, or indirect lighting is to be used and adjust the position of the lower disc accordingly. He may then move the upper disc until the pointer marked against the top space indicates the area of the squares into which the room is assumed to be divided for lighting purposes. A table gives the order of illumination needed for various purposes in practice, and a double circumferential scale, running round the calculating discs enables the lumens corresponding with this illumination to be determined. A second table gives the wattage of lamps required to produce these lumens with ordinary and "half-watt" incandescent lamps respectively.

The apertures on the lower part of the disc then enable the height of suspension to be read off (or in the case of indirect and semi-indirect lighting the distance of suspension from the ceiling).

The method of use, illustrated by a worked example, is set out on the left-hand page, and definitions of the chief photometric quantities are given. A leaflet accompanying the calculator gives fuller details.

It should, of course, be realised that the calculator is essentially adapted to Holophane units, and that, in order to make use of it with intelligence, the operator should understand the fundamental principles of lighting calculations. He ought, for example, to be able to form some idea of the correction to be applied for reflection from walls and ceilings.

The calculator should be of considerable utility to lighting engineers who are constantly engaged in planning Holophane installations, and the method by which the various factors entering into such problems are related in the apparatus is highly ingenious. We notice that the calculator is brought up to date by giving the illuminating values of lamps in lumens—a very desirable step in view of the fact that it applies both to vacuum and gas-filled lamps.

"HOW BETTER LIGHTING YIELDS YOU MORE PROFITS."

Under the above title a very well-got-up little booklet has been issued by the National X-Ray Co. of Chicago. The first page carries a hand with outsttetched fingers labelled respectively "Increased Output," "Less Spoilage," "Fewer Accidents," "Better Working Conditions," "Better Light for Less Money." Looking on, we find several telling sketches under the title, "The Evils of Glare," showing particularly how the worker at the lathe is handicapped if the light shines straight into his eyes instead of falling on the work, and how a man carrying molten metal may easily trip over obstacles on a badly-lighted floor. It is stated that 50 per cent. of all accidents are due to falling. (From the Report of the Home Office Departmental Committee on Lighting in Factories in this country it appeared that at least a very considerable proportion of the accidents are due to this cause in certain trades.) Dr. W. H. Tolman, Director of the American Museum of Safety, is quoted to the effect that adequate lighting would probably prevent 25 per cent. of the existing avoidable accidents in factories.

Several pictorial diagrams illustrate the advisability of using an appropriate reflector to concentrate the light on the work. Finally there is a page devoted to flood-lighting and showing how units of this kind may be applied in the factory to enable unloading work by night gangs to proceed in the open.

BENJAMIN LIGHTING UNITS.

A recent list issued by the Benjamin Electric, Ltd. (1a, Roseberry Avenue, E.C.) contains up-to-date particulars of the firm's lighting units and appliances, especially those for industrial lighting. A particularly useful line is the series of enamelled white vitreous reflectors for use with half-watt lamps, and semi-indirect and special shop-lighting units are also listed.

We notice that within the last few months the page has been increased to standard catalogue size. While some may regret the departure from the very convenient previous dimensions, capable of insertion in the pocket, the larger area of the new page doubtless facilitates the assembly of illustrations, polar curves and data on dimensions, &c., in a more complete manner than hitherto.

OSRAM LAMPS.

A recent list of Osram lamps, issued by the General Electric Co., Ltd., brings the data for ordinary vacuum and gas-filled ("Atmos") lamps up to date.

We note the interesting information that the necessary plant for producing argon gas, which is necessary to ensure maximum efficiency in the smaller sizes of gas-filled lamps, is being erected at the Osram-Robertson Lamp Works at Hammersmith. On the back page is a photo of the Company's glass works at Lemington.

B.T.H. WIRES, CABLES, AND ACCESSORIES.

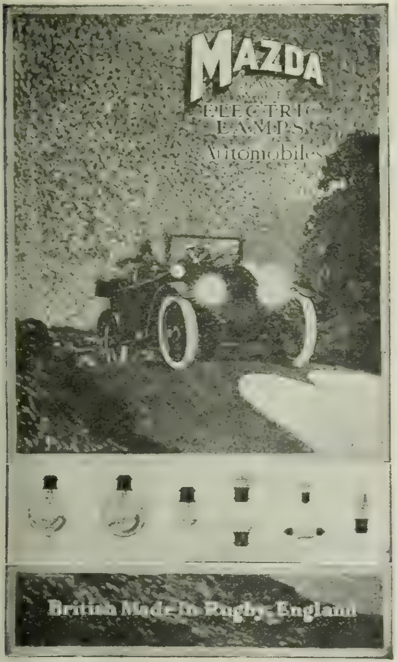
List No. 10800 is concerned with the "Parambo" wires and cables issued by the British Thomson-Houston Co. These wires, cables, and flexibles are made in accordance with the C.M.A. specifications and supplied in great variety.

In view of the appeal from the Cable Makers' Association that contractors during the remainder of the war should use solid instead of small stranded cables, thus releasing stranding machines for war purposes, the catalogue is of special interest.

LAMPS FOR CAR LIGHTING.

We have received from the B. T. H. Co. copies of additional books in their series of incandescent electric lamp handbooks—viz., Nos. 2 and 3 dealing with lamps for battery service (20 volts and below): for automobiles, general batteries, flashlight lamps, and surgical lamps.

These handbooks should be most useful to engineers, contractors, and other users of electric lamps. No. 2 contains a complete glossary of definitions with classifications of lamps, full information and technical data in respect of all types of battery lamps, and detailed dimensional drawings of all the lamps and the lamp caps. In addition, full details and information are given regarding prices and sales terms to the various classes of purchasers,



New B. T. H. Car Lamp Show-Card.

No. 3, the lamp bulb guide for car lighting, is a most comprehensive list and must have entailed a considerable amount of work in preparation. We are particularly struck by the series of tables giving the candlepower, consumption, voltage,etc., of lamps used with pracuically the chief European and American makes of cars.

The L. & W. S. Department of the B. T. H. Co. are desirous of having a copy of this book in the hands of every electrical trader and trade user. Copies of these booklets will be sent on request to the L. & W. S. Department, 77, Upper Thames Street, E.C.4.

The illustration is a reproduction of a show-card of automobile lamps.

We have also to acknowledge the receipt of the latest B. T. H. Heating List (No. 10600A), which describes the Calorite electric fires, luminous radiators, flat irons, kettles, etc.

VARIOUS.

A new battery show-card, executed in four colours, has been issued by the Edison Swan Electric Co., Ltd. (Ponder's End, Middlesex).

Adhesive labels for the use of the trade generally are being issued by the Z Electric Lamp Manufacturing Co., Ltd. These labels are supplied free of charge overprinted with customer's name and address.

We have also received from the same firm a variety of advertising literature relating to catalogues, battery, flashlight, and candle lamps, etc., practically the whole of which can be overprinted free of charge, with the names and addresses of trade buyers.

The offices and stores of the L. P. S. Electrical Co. have been transferred to more commodious premises at 14, Howick Place, Westminster, S.W.1. The new telephone number of the firm is "Victoria 7346."

REVIEW OF BOOK.

"*Welfare Study ; What it is,*" *by Cecil Walton.*

We have had occasion many times during the last year to refer to the admirable work being done by the Welfare Department at the Ministry of Munitions. Without this movement the difficulties of organising large sections of labour in the unfamiliar conditions in munitions factories especially women labour, would have been enormously increased.

The little book by Mr. Cecil Walton explains in a readable manner the nature of welfare work. He illustrates the field of the welfare supervisor by explaining how the worker's needs in such matters as canteens, clothing, recreation, ambulance work, etc., are catered for ; but even more important, perhaps, is the "human touch" introduced in the relations between management and employees. The welfare supervisor, acting as the trusted intermediary between manager and staff, is often able to understand and smooth away causes of friction which might otherwise have developed into serious trouble ; in other cases, however, where the employees are clearly at fault, the evidence of the welfare supervisor has naturally great weight in showing that the management's attitude is not unreasonable.

The booklet is illustrated by a number of photographs showing the nature of work, canteen arrangements, etc., in munitions factories. It is interesting to note that, by the scientific economy of effort, women munitions workers are now able to deal with the larger types of shells, of a size which it would have been judged impossible for women to handle before the war.

Most people, we believe, who study this movement will heartily endorse Mr. Walton's terse statement: "Welfare ! It pays, Sir, every time !"

We may add that full particulars of welfare organization will be furnished to anyone interested in the subject who applies to the Ministry of Munitions, Welfare Section, 11, Whitehall Gardens, London, S.W.1.

EXHIBITION OF MUNITIONS WORK.

An exhibition was opened in the Building of the Royal Colonial Institute, London, on March 26th, under the supervision of the Ministry of Munitions, relating specially to women's work. Visitors had an opportunity of appreciating the variety of operations in munitions work now carried on by women, and a number of technical photographs furnished a useful record of the progress made in this direction since the outbreak of war.

PERSONAL.

Mr. B. J. Grigsby, A.M.I.E.E., who was associated with the Benjamin Electric, Ltd., London, from 1908 onwards, returned last December to the United States, where he is now vice-president and general manager of the Anderson Electric Speciality Co., 562—564, West Van Buren Street, Chicago.

Mr. G. L. F. Philips, Glow lamp works, Eindhoven, Holland, has been nominated Doctor *honoris causa* by the Senate of the Technical University at Delft.

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F. NORIE-MILLER, J.P.
General Manager.

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LIGHTING REGULATIONS FOR LONDON.

In an Order issued by the Home Secretary early in the present year it was laid down that :—

(1) Any public lamp or lamps in the Metropolitan Area Police District or the City of London, which the Commissioner of Police, acting on the advice of the Field Marshal Commanding-in-Chief, Home Forces, directs to be lighted or retained in lighting, must be lighted accordingly, and must be reduced, shaded or obscured as the Commissioner of Police may direct.

(2) The Lights (London) Order of August 26th, 1916, shall, except as otherwise provided in paragraphs (5) and (6) thereof, apply as follows :—

From 6 p.m. till one hour before sunrise during January, 1917.
From 6.30 p.m. till one hour before sunrise during February, 1917.
From 7.30 p.m. till one hour before sunrise during March, 1917.
From 8.30 p.m. till one hour before sunrise during April, 1917.*
From 9 p.m. till one hour before sunrise during May, 1917.*
From 9.30 p.m. till one hour before sunrise during June, 1917.*
From 9 p.m. till one hour before sunrise during July, 1917.*
From 8.30 p.m. till one hour before sunrise during August, 1917.*
From 7.30 p.m. till one hour before sunrise during September, 1917.*

* These times will be advanced by one hour during the period covered by the Summer Time Act.

ELECTRIC LAMP GLASS.

The Ministry of Munitions has issued Orders prohibiting the manufacture of electric lamp glass unless the purpose for which such glass is required has been approved.

Applications in reference to this matter should be addressed to the Director of Optical Munitions and Glassware Supply, Ministry of Munitions of War, 117, Piccadilly, W.

ELECTRIC POWER SUPPLY.

The President of the Board of Trade has appointed a Committee to consider and report what steps should be taken, whether by legislation or otherwise, to ensure that there shall be an adequate and economical supply of electric power for all classes of consumers in the United Kingdom, particularly industries which depend upon a cheap supply of power for their development. All communications should be addressed to the Secretary, Mr. M. J. Collins, Board of Trade, 7, Whitehall Gardens, London, S.W.

SUMMER TIME (DAYLIGHT SAVING) ACT.

A Report has been issued by the Committee appointed by the Home Secretary to enquire into the social and economic results of the Summer Time Act, 1916.

The Report covers wide ground, witnesses being examined representative of many diverse interests, including agriculture, education, gas and electric supply undertakings, employers, and trade unions, &c.

Taking the evidence as a whole the Committee find a preponderance of opinion in favour of the Act, not only as a war measure but as a permanent institution. It is therefore recommended that the Act should again come into force during the present year, and that its operation should cover the period from the second Sunday in April to the third Sunday in September.

In accordance with the Report of the Committee the Act came into force on Sunday evening, April 8th.

USE OF GAS IN THE METAL INDUSTRY.

At the Annual Meeting of the Institute of Metals on March 22nd, a series of papers illustrating the applications of gas for various metallurgical purposes were read. These include :—"Coal gas as a fuel for melting non-ferrous alloys," by G. B. Brook ; "Metal-melting by means of high pressure gas," by C. M. Walter ; "Metal-melting as practised in the Royal Mint," by W. J. Hocking ; "The melting of brass and copper in a crucible furnace with coal gas fuel," by H. M. Thornton and H. Hartley.

·ELECTRICITY· ·ACETYLENE·
The
ILLUMINATING
ENGINEER
·OIL· ·GAS·
Edited by
LEON GASTER

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EDITORIAL.

The Annual Meeting of the Illuminating Engineering Society.

At the Annual Meeting of the Illuminating Engineering Society on May 15th the Report of the Council summarised the chief events of the session 1916-1917—the third year of the war.

The experience in regard to illuminating engineering was broadly similar to that recorded for the previous year, but the effect of the continued hostilities has been accentuated in various ways. Many aspects of illuminating engineering are necessarily in abeyance, and the choice of subjects for discussion of special interest at the present time was therefore timely. On the other hand, new fields for work have opened up. The Society has now several committees engaged in work for Government Departments, it has been invited to form a committee to co-operate with the Cinema Commission in regard to the lighting of cinematograph theatres ; and it is represented on the London Safety First Council, which is studying the relation of street-lighting to safety and the prevention of accidents, and has already done good work in facilitating the uniformity of public lighting throughout the metropolitan area. The modifications in street-lighting recently introduced mark a distinct advance from the illuminating engineering standpoint, and the agreement on uniformity of practice throughout London is a significant precedent for the future.

The Society has suffered the loss of several valued members. The death of Professor Silvanus P. Thompson, which occurred shortly after the Annual Meeting last year, has been deeply felt, not only by the Society, but by the world of science. We are glad to note that the Council is considering an appropriate method of recognising his great services as President during the first four years of the Society's existence. Sir William Bennett, the President for the past two years, has taken a keen interest in the Society's work, in spite of many urgent calls upon his time for special and responsible war work. In thanking him for his services at the Annual Meeting Mr. F. W. Goodenough, the Chairman of Council, announced the nomination of Mr. A. P. Trotter as President for the coming session. Mr. Trotter's name is familiar to everyone interested in photometry and illumination, which has been his special study for many years. He has already rendered countless services to the Society at meetings, on the Council and on Committees, and his election as President will be greeted with acclamation by all the members of the Society, and all will agree that it is a privilege for the Society to have the benefit of his large experience and profound knowledge of lighting problems.

The most important announcement in the Report of the Council related to the formation, under the Department of Scientific and Industrial Research, of a Joint Committee on Illuminating Engineering of which, very opportunely, Mr. Trotter is the Chairman. The Report of the Research Committee of the Society, presented at the Annual Meeting last year, paved the way for this step and formed a basis for the statement of the Deputation which approached the Department on this matter on March 3rd. The appointment of the Joint Committee is a gratifying recognition of the importance of illuminating engineering as a field for research, and it is very satisfactory to note that the valuable work being carried on under the Department in many other fields is now to be extended to illumination.

Following the conclusion of formal business, a discussion took place on "Economies in Lighting in relation to Fuel-Saving." The account of this discussion will appear in our next issue, and we must defer detailed comment until then.

The chief point elucidated in the discussion was the comparatively small consumption of coal for lighting by supply companies, which, apparently, does not exceed six million tons per annum, *i.e.*, only 2½ per cent. of the total coal output. It is evident, therefore, that the prospects of saving in this field are not great compared with those existing in connection with power-supply and other sections of coal expenditure.

Nevertheless, the elimination of waste of light by improper use, which has always been an aim of the Illuminating Engineering Society, deserves attention, and it was suggested that the matter might be the subject of enquiry by a Joint Committee during the coming months.

Gas and Electric Supply Companies and Public Service.

We have often emphasised the idea that the duties of supply companies should include the study of the consumer's interests and the giving of advice as to the best use of the commodity supplied to him.

Supply companies have a public service to perform, and are necessarily dependent upon the public goodwill. A case in point is afforded by an experience of Mr. C. E. Clewell in the United States, which forms the subject of a note on pp. 117-118 in this issue.

The company concerned had taken over a plant previously privately owned, and found the administration in a bad state. The methods of assessment and collection of accounts were lax, the conditions of distribution were faulty, and there was little sign of appreciation on the part of consumers of the fundamental principles of good lighting. The new company set about reforms and promised better service at a lower cost. It appears, however, that the reforms in collecting accounts at first outran those in other directions. The consumers complained that their bills had increased and that the service had not improved. The company then asked Mr. Clewell to make an exhaustive enquiry, and he suggested a number of improvements practically all of which were energetically taken up, but in the subsequent two years they were unable to make good the lost ground. Eventually a petition in favour of the supply being taken over by the municipality was presented. At the hearing of this petition it was evident that some of the complaining consumers had no conception of the essentials of good lighting, and the company, on their side, were apparently not well equipped in staff and knowledge to meet charges under this head. The moral drawn by Mr. Clewell is that " poor lighting leads to public ownership." A company must render public service if it is to continue to exist.

In the future gas and electric supply companies will doubtless demand new opportunities for expansion, and the removal of restrictions which have hampered their development in the past. Mr. Vernier in his recent paper before the Institution of Electrical Engineers on " Wayleaves " contended that supply companies should be regarded not as mere dividend-earning concerns, but as doing an important public service. In order to justify this description companies must be prepared to cultivate more friendly relations with the consumer. The machinery of complaint departments should be overhauled. A satisfied consumer is a continual advertisement, a dissatisfied one a constant source of trouble. The more progressive companies no doubt take special pains to secure people of tactful personality and agreeable manners for such posts. Men or women entrusted with this work should be thoroughly trained in the technical side of the business and familiar with the standpoint of the consumer. Adequate salaries should be paid in order to place them in an independent position and above any possible reproach of yielding to undue influences. While loyal to the Company's interests they should not be too ready to assume that the consumer is wrong, but should hear all complaints with patience and courtesy and endeavour to remove misunderstanding rather than enforce routine procedure.

The Properties and Applications of Selenium.

On pp. 115-116 in this issue we refer to an interesting paper recently read before the Röntgen Society by Mr. E. Fournier D'Albe, dealing with the properties and applications of selenium. This substance has many possible applications, most of them, however, still in the experimental state. The author mentions one very striking example of its use, *i.e.*, to measure the light from distant stars. He contends that selenium is more sensitive to light than the human eye and that it might be possible, by proper appliances, to recognise the existence of faint distant stars such as cannot be seen by the eye even with aid of the most powerful telescope. This, if confirmed, is a remarkable result.

Among other applications are the use of selenium for the transmission of photographs by wire, its possible application to multiple telegraphy, and its employment in such devices as the optophone, which Mr. Fournier D'Albe has endeavoured to apply to enable the blind to read. It has also been used for the automatic extinction and lighting up of lights on buoys and beacons and it might conceivably be applied to control the artificial lighting of a factory, operating a switch by turning on the lights when the daylight illumination has fallen to a prescribed value. In a discussion before the Illuminating Engineering Society in 1916 Dr. Marchant communicated some particulars of a device involving the application of selenium cells to the control of street lamps, due to Mr. C. J. Turner of Hoylake. Up to a point the use of selenium for the automatic control of artificial light, as well as to photometry, appears promising. There are, however, difficulties to be overcome. One of the chief of these is the well-known "inertia" of selenium, which causes its sensitiveness to alter after exposure to bright light. The results at any moment are thus to some extent dependent upon its previous history. Another property which is not so serious when purely relative photometric observations are concerned, but obviously limits its application to comparisons between different types of lamps, is that it is, to some extent, "colour-blind," *i.e.*, it reacts to light of various colours in a manner quite different from that of the human eye. Another fact of importance, mentioned by Mr. Thorne Baker in the discussion of Mr. Fournier D'Albe's paper, is that selenium is apparently affected by atmospheric conditions. On a given day, for example, cells prepared in an identical manner gave different results in London, Paris and Manchester.

The study of all these peculiarities of selenium offers a most profitable field for investigation. Their examination demands the combined efforts of the chemist, the physicist and the photometric expert, and there seems no reason why selenium should not eventually be prepared in such a way as to be free from the present inconvenient properties. That there is room for development in this direction is apparently indicated from some results described in a recent American patent, also summarised in this issue (p. 116). The patentee claims to have prepared cells a thousand times as sensitive as those hitherto in use, and with a sensibility which remains unaltered over long periods of time. We shall await with interest further particulars of these and other investigations in this field.

LEON GASTER.

TRANSACTIONS

OF

The Illuminating Engineering Society.

(Founded in London, 1909.)

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

ANNUAL MEETING.

(Proceedings at the Annual Meeting held at the House of the Royal Society of Arts, 18, John Street, Adelphi, W., at 5 p.m., on Tuesday, May 15th, 1917.)

The Annual Meeting of the Society took place, as stated above, on Tuesday, May 15th, Mr. F. M. Goodenough (Chairman of Council) presiding.

The minutes of the last meeting having been taken as read, the HON. SECRETARY read out the following names of applicants for membership:—

Cross, P. H. ..	.. Electrical Engineer, 65, Tooting Bec Road, S.W.
Glew, F. Harrison	.. Chemist and Radiographer, 156, Clapham Road, S.W.
Iverson, H. ..	.. Engineer, 22, Hermiston Avenue, Hornsey, N.
Landau, A. L. ..	.. Chemist, 24, Leigh Road, Highbury Barn, N.5.
Pepper, W. J. ..	.. Inspector-in-Charge, The Gas Light and Coke Co., 182, Edgware Road, London, W.

REPORT OF COUNCIL.

The CHAIRMAN then called upon the HON. SECRETARY to read the Annual Report of the Council for the Session November 1916—May 1917 (see pp. 104-107), which contained the announcement that a Joint Committee on Illuminating Engineering had been formed under the Department of Scientific and Industrial Research. At the Annual Meeting in 1916 the Committee of the Society on Research had drawn up a list of subjects deserving of investigation. The appointment of the Joint Committee was the result of a Deputation from the Society, introduced by the President, which was received at the Department on March 6th in this year.

The resolution—" That the Report of the Council for the Session November 1916—May 1917 be formally adopted by the Society "—was then proposed by the Chairman, seconded by Mr. A. P. Trotter, and declared carried unanimously.

Mr. A. P. TROTTER, in seconding the adoption of the Report, explained the steps leading to the formation of this Committee, which would doubtless stimulate research on illuminating engineering. It was naturally desirable to devote attention first to subjects of national or immediate industrial importance, but the field of work could be enlarged in time to come.

VOTE OF THANKS TO PRESIDENT, OFFICERS AND COUNCIL.

Mr. J. F. CROWLEY then proposed: "That this Meeting extends a cordial vote of thanks to the President, Council and Officers of the Society for their efforts on behalf of the Society during the past twelve months."

In commenting upon the Annual Report, Mr. CROWLEY congratulated the Council on the continuation of the work of the Society in spite of all the difficulties incidental to the war. He thought they had made a wise choice of subjects for discussion. In the present circumstances the selection was naturally somewhat limited, partly because the consideration of many topics which would ordinarily interest the Society had to be deferred at the present moment, and partly because on other subjects connected with the war they could not say as much as they would like.

The virility of the movement was shown by the appointment of the Joint Committee under the Department of Industrial and Scientific and Industrial Research which should lead to valuable results.

Mr. SHAW SCOTT, who seconded, also referred to the Joint Committee, and referred to the valuable work being done under the Department in other fields which, he was glad to see, would now be extended to illuminating engineering.

The resolution was declared carried unanimously, and Mr. L. GASTER (Hon. Secretary) briefly returned thanks on behalf of the Council.

ELECTION OF MR. A. P. TROTTER AS PRESIDENT.

The CHAIRMAN (Mr. F. W. Goodenough) referred in appreciative terms to the services during the past two years of Sir William Bennett as President. In spite of many urgent calls on his time owing to important and responsible war work, Sir William had yet found leisure to render very material help to the Society. In view of the nature of the subjects for discussion, the selection of a distinguished medical man as President had been opportune, and he felt that the Society owed a debt of gratitude to Sir William for his interest in the Society's work, and the aid he had given to them on a number of occasions, notably in introducing the Deputation to the Department of Scientific and Industrial Research.

He had now a pleasant duty to perform. At a recent meeting the Council had unanimously nominated Mr. A. P. Trotter as the President for the forthcoming year, and it fell to him to formally propose his election. There was no need for him to dwell on Mr. Trotter's long-standing association with photometry and illumination, and his constant interest in the work of the Society since its formation in 1909. At the present moment his election as President was rendered specially opportune by the fact that Mr. Trotter was also the Chairman of the Joint Committee on Illuminating Engineering, to which reference had been made.

Mr. L. GASTER, in seconding the resolution, recalled that when a meeting was called to consider the formation of the Society in November, 1907, Mr. A. P. Trotter, in the unavoidable absence of Sir William Preece, had consented to occupy the Chair. Ever since he had taken an active part in the work of the Society, both at meetings, on the Council, and on Committees, and the Society already owed much to his zeal on its behalf.

The election of Mr. Trotter as President having been carried with acclamation, Mr. TROTTER briefly expressed his appreciation of the honour of becoming President, and, Mr. Goodenough being called away shortly afterwards, occupied the chair for the remainder of the meeting.

The formal business before the meeting was terminated by the following vote of thanks to the Royal Society of Arts, which was proposed by Mr. TROTTER, seconded by Mr. GOODENOUGH, and declared carried unanimously:—

> "That this meeting desires to express a cordial vote of thanks to the Royal Society of Arts for the courteous permission to make use of their rooms

during the past session, and records its appreciation of the encouragement and support which the Society has received."

ECONOMIES IN LIGHTING IN RELATION IN FUEL-SAVING.

The Chairman then called upon Mr. L. Gaster to open the discussion on "Economies in Lighting in Relation to Fuel-saving."

Mr. GASTER, while dwelling on the need for fuel-saving in the present unprecedented circumstances, remarked that economy in lighting, in the sense of proper use of light and avoidance of waste, had always been a feature of the Society's programme. He quoted some figures relating to the coal supply of the United Kingdom, and referred to the experience of the Summer Time Act, by which a small but appreciable fuel-saving, varying however according to the nature of the district, had been recorded.

The problem would become of special interest in the winter months, and he thought that the intervening period might be utilised to consider where savings could profitably be effected. It seemed desirable to make a rough classification of lighting somewhat as follows :—

(1) Safety (*i.e.*, the use of illumination with a view to preventing accidents).

(2) The use of illumination in factories, munition works, and for other indispensable purposes.

(3) The use of illumination in the interests of public convenience.

(4) The use of light for luxury and spectacular purposes.

It was clearly undesirable to interfere with the use of light for the two first purposes, and the third category should also be left untouched except in urgent need, but in the fourth category some economies might possibly be made.

Any regulations with a view to making economies in lighting should follow broadly this classification, restrictions being applied in the order indicated.

The whole subject might well form the subject of consideration by a Joint Committee, acting with the support of the authorities, on which the Society should be represented. Such a Committee working during the coming months might accumulate information which would be not only of present utility but also of value for the future.

In the ensuing discussion the Assistant Hon. Secretary read a written contribution from Mr. Faraday Proctor, summarising some of the conclusions arrived at as a result of experience in connection with the Summer Time Act, and urging the economical use of fuel for power-production, especially through generation on a large scale rather than by the wasteful methods often pursued by small users.

Mr. J. F. CROWLEY likewise referred to the desirability of economies in power-production, seeing that lighting was responsible for such a relatively small proportion of the total fuel-consumption.

Mr. J. S. DOW remarked that although the saving in fuel to be achieved through diminished lighting might be small, the margin of fuel available for this purpose was also restricted. It was therefore essential that the best field for economy should be carefully selected. The avoidance of waste of light, which was one of the aims of the Society, was an aim worth pursuing at all times, but especially so at present.

The CHAIRMAN referred to some of the problems involved in fuel-saving, and quoted some data to show the relatively small expenditure of coal for lighting.

He also referred to the waste in some prevailing methods of street-lighting, especially the use of arc lamps, the globes of which had been almost completely obscured.

As regards the Committee, he thought he would be voicing the views of the meeting in suggesting that this matter might be safely left in the hands of the Hon. Secretary, who would no doubt take all necessary steps.

Mr. L. GASTER having briefly replied, the proceedings terminated, the CHAIRMAN announcing that the first meeting of the coming session would be held in November.

[*The full account of the Discussion on "Economies in Lighting in relation to Fuel Supply" will appear in our next number.*—ED.]

REPORT OF THE COUNCIL FOR THE SESSION (November 1916 – May 1917).

(Presented at the Annual Meeting of the Society held at the House of the Royal Society of Arts, London, at 5 p.m., on Tuesday, May 15th, 1917.)

THE Report of the Council for the Session 1916—1917 appears in the third year of war and the circumstances alluded to in the Reports for the last two years continue. A number of members have joined the Colours, and there have been further additions to the number of those engaged wholly or partly on special war work. Nevertheless the activities of the Society have been continued without intermission.

MEMBERSHIP.

During the past year the membership has been well maintained. It is hoped, however, that in view of the increasing recognition of the value of the movement, further support will be forthcoming from companies throughout the country engaged in the supply of gas and electricity.

We have pleasure in recording that the Presidents of the Institutions of Gas and Electrical Engineers, Mr. A. E. Broadberry and Mr. C. P. Sparks, have kindly consented to act on the Council during their tenure of office.

Mr. A. E. Broadberry (President of the Institution of Gas Engineers), Mr. Harry E. Jones (President of the National Gas Council), and Mr. D. Milne Watson (Managing Director of the Gas Light and Coke Co.) have been created Vice-Presidents, and Professor A. Blondel has been nominated an Hon. Member of the Society in recognition of distinguished services rendered to the study of illumination and as one of the leading French scientists interested in this field.

The Society has sustained a great loss in the death of Professor Silvanus P. Thompson, whose able conduct of the affairs of the Society during its first four years of existence will not soon be forgotten. The Council desire to take this opportunity of again gratefully acknowledging these services, and are now considering an appropriate method of commemorating his name in connection with the Society.

In the death of Sir Corbet Woodall, the late Governor of the Gas Light and Coke Co., the gas industry has lost a distinguished representative, and the Society a valued Honorary Member. The Society has also lost through death two eminent Corresponding Members, Professor S. A. Rumi, of Genoa, and Professor Dr. Erismann, of Zurich, while several of its younger members, Mr. E. C. Laughton, Mr. A. L. Jones and Dr. Schwabacher, have fallen in the war.

MEETINGS OF THE SOCIETY.

Four meetings, not including the Annual Meeting, have been held during the Session.

At the opening meeting on December 15th, the Hon. Secretary gave an address on " Some Events during the Vacation, with Special Reference to War Economies in Lighting," in which reference was made to various points of topical interest such as Daylight Saving, Economy in Artificial Light, and Conditions of Illumination in the Streets, with special reference to accidents.

Mr. H. Blain, who was present on behalf of the London Safety First Council, expressed his recognition of the relation between defective lighting conditions and traffic accidents, and conveyed to the Society an invitation to be represented on the Council. The Society has since been represented on the London Safety First Council by its Hon. Secretary, who, in conjunction with the Chairman of Council, is likewise a member of the Sub-Committee on Street Lighting.

A record is being kept of present developments in street lighting, which will no doubt be of considerable interest in the future.

The second meeting on January 16th was given up to a discussion on "The Lumen as a Measure of Illuminating Power," opened by Professor J. T. McGregor-Morris and Mr. F. W. Willcox. In view of the decision taken at the last Convention of the American Illuminating Engineering Society to rate lamps in terms of lumens, and the proposal of the makers of electric incandescent lamps in this country to adopt the same method of rating, this subject was opportune. In the course of the discussion the view was expressed that a descriptive pamphlet containing an explanation of the nature and use of the lumen would be useful in making this unit more generally known, and it was suggested that a small Committee of the Illuminating Engineering Society should be formed to draw up such a pamphlet. This proposal has been receiving the attention of the Council, and it is intended to proceed with this matter during the Vacation, preparatory to the coming lighting season.

On February 20th a paper was read by Dr. James Kerr, on "The Effect on the Eye of Varying Degrees of Brightness and Contrast." The paper and discussion were useful in bringing up to date our knowledge on the subject of effects of glare and contrast—matters which formed the subject of one of the first discussions before the Society in 1910. Earlier views on this subject have been revised as a result of fuller consideration of the effect of adaptation of the eye. It was shown that the principles discussed have an important bearing on many practical problems, such as the restricted lighting conditions in streets, and the illumination of the auditorium and screen in cinema theatres.

In connection with the latter aspect of the subject, two members of the Cinema Commission Enquiry, Dr. C. W. Kimmins and Mr. A. E. Newbould, were present, and conveyed to the Society a request from the Commission that a representative should give evidence before the Commission, and that the Society should appoint some of its members to co-operate with the Commission on a small committee to study lighting problems in cinema theatres.

It is hoped that the formation of such a Committee will be taken up with the co-operation of the cinematograph industry shortly.

On March 22nd a discussion was opened by Mr. F. Harrison Glew on "Fluorescence and Phosphorescence and their use to produce luminous effects." Mr. A. Blok and Mr. J. S. Dow dealt respectively with the photometry of such substances and their practical applications. At this meeting Mr. F. J. Cheshire (Director of Optical Glassware and Munitions Supply, Ministry of Munitions of War) presided. Apart from its great scientific interest, and its relation to the fundamental principles underlying the production of light by illuminants, the discussion formed a useful supplement to Dr. Kerr's paper, illustrating some of the properties of the eye which come into play at low illuminations. Interesting demonstrations were arranged by Mr. F. H. Glew, Mr. A. Blok, Mr. A. L. Landau, and Mr. C. C. Paterson.

It will be observed that during the past session the discussions have dealt with special topics arising through war conditions or problems which are exciting general interest at the present moment.

SCIENTIFIC WORK FOR THE WAR.

Committees of the Society have been engaged in experimental work on certain special investigations for Government Departments in connection with the war, and many individual members have been employed on such work.

SCIENTIFIC AND INDUSTRIAL RESEARCH.

The Department for Scientific and Industrial Research has been established by the Privy Council to assist in those investigations and developments which are beyond the reach of any one firm, or can best be carried out by combination of experience and co-ordination of work. The Research Committee of this Society has already prepared a list of subjects requiring attention, some of them being of pressing importance owing to the war. It was resolved to approach the Department, and a deputation of the Society was received on March 6th by Sir Wm. McCormick, the Chairman of the Advisory Council, at the offices of the Department in Great George Street, Westminster.

The Deputation consisted of the following officers and members of the Society:—

Sir William Bennett, K.C.V.O., F.R.C.S. (President).
Mr. A. P. Trotter (Senior Vice-President).
Mr. F. W. Goodenough (Chairman of Council).
Mr. Frank Bailey (Vice-Chairman of Council).
Mr. L. Gaster (Hon. Secretary).
Mr. A. Blok (Optical Glass Dept., Ministry of Munitions).
Lieut. S. R. Mullard, R.N.V.R. (R.N.A.S. Laboratories, Imperial College of Science, and Edison and Swan Lamp Research Dept.).

Each member contributed some account of the work in which he was interested and pointed out the directions in which research is needed.

The Deputation asked the Department to form a Joint Committee to deal with Illuminating Engineering. It was pointed out that the Society is in a specially favourable position to co-operate in such work, in view of the representative character of its membership, including gas and electrical supply companies, manufacturers of lamps and lighting appliances, and scientific experts.

Sir William McCormick, on behalf of the Advisory Council, promised to give the proposals of the Deputation favourable consideration and the result was the appointment of a Joint Committee on Illuminating Engineering, working under the Department. For the purpose of bringing it into touch with existing Committees members of the Engineering and of the Glass Committees were included.

The members of the Joint Committee are:—

Mr. A. P. Trotter (Chairman).
Sir Maurice Fitzmaurice, Mr. J. S. Highfield (representing the Standing Committee on Engineering).
Professor Herbert Jackson, Professor C. V. Boys (representing the Standing Committee on Glass and Optical Instruments).
Dr. C. Carpenter (South Metropolitan Gas Co.).
Mr. Leon Gaster (Illuminating Engineer).
Mr. F. W. Goodenough (Chairman of Council, Illuminating Engineering Society)
Captain J. H. Parsons, F.R.C.S. (Ophthalmic Surgeon).
Sir John Snell (Electrical Engineer).

The Committee has held its first meeting, the general procedure was discussed, and steps were taken to proceed with inquiries about those problems demanding urgent attention.

The formation of this Joint Committee under the Department of Scientific and Industrial Research is an important recognition of the aims of the Society, and there is every reason to hope that the extension to Illuminating Engineering of the valuable work already being done under the Department will be productive of useful results. For the moment it may be necessary to proceed first with investigations of national or immediate industrial value, but after the war, when the work of the Joint Committee will have developed, the range of subjects dealt with can be enlarged. The fact that machinery for the encouragement of researches now exists in the wide field of illuminating engineering is an important step.

EVENTS DURING THE PAST YEAR.

As on the occasion of our last Report, there is again little to be said regarding International Congresses, which are naturally in abeyance owing to the war.

The Illuminating Engineering Society in the United States has been continuing its work with full activity. The Annual Convention was held in Philadelphia last September, and a series of lectures on illuminating engineering was given at the Pennsylvania University. These lectures will form a useful supplement to those dealing mainly with general principles, which were delivered at the Johns Hopkins University, Baltimore, in 1910.

Reference has been made to the resolution adopted regarding the rating of illuminants in terms of lumens at this Convention. Another item of interest was the presentation of the Report of the Committee on Nomenclature and Standards proposing a complete series of symbols, terms and definitions—a subject which has already received attention at the hands of our Society

In this country the course of events in regard to illuminating engineering has been broadly similar to that recorded for 1915-1916. The demands of the war have naturally caused many aspects of lighting to sink into abeyance, but other special fields of usefulness for the Society have been opened.

The relation between the diminished public lighting and the increased number of accidents in the streets has been the subject of discussion. Some statistics on the subject have been published in THE ILLUMINATING ENGINEER.* With a view to future progress in street-lighting it is desirable that these data should be amplified so that the relation between illumination and safety in the streets can be more clearly traced.

The recognition of this relation has been largely instrumental in bringing home the aims of the Safety First movement through which the municipal authorities throughout London have been brought into cooperation, with a view to treating street-lighting on a common basis. The recent alteration in the lighting conditions is, chiefly through this movement, being carried out in a uniform manner throughout the Metropolitan area. This is the first occasion on which the lighting of London has been dealt with as a whole and should serve as a significant precedent for the future.

Another step of importance has been the issue of the Report of the Committee appointed by the Home Secretary to inquire into the social and economic results of the Summer Time Act (1916). The Act has been extended to the present year, and it seems probable that the arrangement will be continued after the termination of the war.

The desirability of bringing about a further economy in fuel-consumption has led the Government to inquire into the directions in which economies in lighting may fitly be exercised. This subject is to be discussed at the Annual Meeting. It appears very desirable that any such modifications in lighting should be carefully considered during the summer period with a view to securing a minimum interference with safety and convenience during the winter months.

ADDITIONAL SUPPORT REQUIRED.

The Council are glad to be again able to record the gratifying fact of the Society being able to continue its labours, in spite of the unprecedented circumstances arising through the war. The considerations referred to under this head in their last Report apply with added force to the period 1916-1917. The Society is fortunate in benefiting by the arrangement by providing for THE ILLUMINATING ENGINEER to act as the official organ, and to undertake the publication of transactions the cost of which would otherwise be prohibitive. Many of the expenses incurred, such as those in regard to paper, printing, &c., have increased very greatly. The experience of the past year has served to emphasise even more strongly the desirability of securing additional funds in order to enable the work of the Society to be carried on in a satisfactory manner.

During the present circumstances the Council, as stated in their Report for the previous year, are unwilling to recommend any radical departure in this respect, but it is becoming evident that in the near future the Society must either secure a considerably enlarged membership or increase its present moderate subscription to £2 2s., as was originally provided at the time of the foundation of the Society, or secure substantial support from such institutions as benefit directly from the movement.

Another circumstance which has added to the difficulties of the present period is the considerable number of members who have joined the forces and from whom for the moment subscriptions may not be available. It is earnestly hoped that members who are still free to follow the work of the Society will aid the Officers of the Society in their task by prompt payment of subscriptions.

PROGRAMME FOR THE NEXT SESSION.

The Council is now engaged in preparing the programme for the next session. Members who are willing to read Papers are invited to notify the Hon. Secretary as soon as possible and to send in contributions during the vacation.

WILLIAM H. BENNETT, *President.*
F. W. GOODENOUGH, *Chairman*
LEON GASTER, *Secretary.*

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* November, 1916, p. 334; February, 1917, p. 38.

BRITISH SCIENCE GUILD.

Eleventh Annual Meeting.

On April 30th the Eleventh Annual Meeting of the British Science Guild took place at the Mansion House, the Rt. Hon. the Lord Mayor in the chair.

Sir Wm. Mather, the President, in announcing his retirement, introduced Lord Sydenham, as the President for the coming year.

The adoption of the Annual Report was moved by Sir Boverton Redwood, and seconded by Prof. R. A. Gregory. As usual, the report contains a useful summary of recent events in the direction of the application of science to industry and national needs, one item being a summary of the very considerable number of scientific committees which are now assisting the Government. In view of the creation of the Department of Scientific and Industrial Research it is also interesting to have on record corresponding steps being taken in Canada, Australia, and the United States. In France the Academy of Sciences has passed a resolution urging the institution of a National Research Laboratory, in view of the fact that at present there is in France no national laboratory with similar equipment and resources to those in England, United States, and Germany.

An address on National Reconstruction was given by Lord Sydenham, who pointed out many instances of the results of the national neglect of science, and mentioned many opportunities for its application in the future. The Empire contains all the great stable food supplies, raw materials of industry, and many rare metals, and even within the British Isles there are many sources of power at present untapped.

In advocating the fuller representation of science in the schools and universities, Lord Sydenham observed that scientific education was in no way antagonistic to the humanities.

The same view was expressed in the address by the Rt. Hon. H. A. L. Fisher, who said that technical and scientific training should be of such a character as to provide a liberal education as well as developing special abilities. Such a training should develop the sense of discipline and citizenship quite as effectually as the older educational systems. While our methods of teaching science in the schools were often considered well devised, we had not yet succeeded in making an appeal to the imagination of children and in leading them to apply their scientific knowledge in after life.

Mr. H. G. Wells declared that the great obstacle to educational reform was the over-emphasis of the importance of classical studies. Not only were too many hours expended in Latin and Greek, but the best teachers were always on the classical side, and the most gifted boys were attracted by scholarships, just as the ablest men were encouraged to devote themselves to classics as a preliminary to entering the public service.

As a result, the men in whose hands the destinies of the country rested were often without adequate knowledge of science and its possible applications.

He did not undervalue the beauty and worth of ancient philosophy and other knowledge derived through classical studies, but the path to such knowledge was often barred for ordinary men by the needless insistence that it could only be attained through the medium of the Latin and Greek languages. Thus a gulf was opened between scientific men and scholars, and neither could properly appreciate the other's point of view.

THE FUNDAMENTAL PRINCIPLES OF GOOD LIGHTING.

By P. G. Nutting.*

In our last number we gave a summary of some of the chief conclusions as regards the production of glare and the effect of contrast, arrived at by Mr. P. G. Nutting. The present article is based on some supplementary data given in a recent contribution by the same author in the Franklin Institute (March, 1917).

The article in our March issue contained a résumé of Mr. Nutting's conclusions on the effect of brightness on the three fundamental factors in vision, termed respectively *photometric sensibility*, *threshold sensibility*, and *glare sensibility*.

Effect of Brightness on Sensibility of Eye.

All these factors are shown to change progressively as the order of brightness increases. Fig. 1 illustrates the relation between stimulus and (*a*) total sensation, and (*b*) "sensibility," (*i e.*, the reciprocal of the percentage variation in brightness just perceptible).

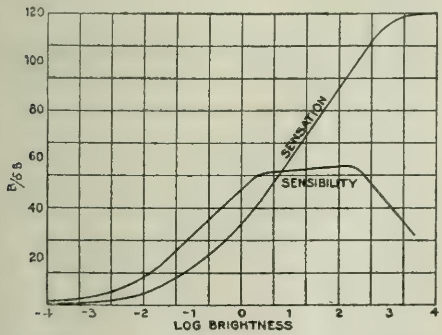

Fig. 1.—Showing relation between sensation and sensibility (power of eye to perceive contrast, B/dB), and brightness of field (millilamberts, B). Sensibility is expressed as a percentage; brightness in millilamberts is plotted on a logarithmic scale.

Owing to the vast range of brightness to be covered the data on the abscisas scale are put in the form of logarithms, but it will be observed :—

(1) That the sensibility rises comparatively slowly from zero to about 1/100th of a millilambert (roughly equivalent to 1/100th foot-candle on a white surface).

(2) The increase is rapid from 1/100th of a millilambert up to about 10 millilamberts.

(3) From this value up to 100 millilamberts there is very little gain in sensibility, the curve becoming almost flat.

(4) Above 100 millilamberts the curve soon turns downwards, showing that increased illumination, so far from being a help, actually reduces the sensibility.

One can appreciate from these curves how a higher illumination becomes necessary for fine work involving slight contrasts, while a relatively low illumination suffices for handling large objects, or in dealing with black and white.

We can also understand why, when type is printed on dark-coloured paper, or on light paper with insufficiently dark ink or when dark materials are sewed with dark cotton, the illumination needs to be so much increased. For in such a case we reduce enormously the contrast between the working materials, and must therefore call for a higher order of illumination to enable this diminished contrast to be perceived.

Such data as the above appear to suggest a working basis for experiments on the amount of illumination required for various industrial purposes.

Ratio of Brightness Causing Glare.

In the next figure we have, also in a logarithmic form for the sake of convenience, not only the sensibility of "discrimination" curve just described, but also the corresponding curves for the threshold sensibility and the glare sensibility which were assembled in tabular form on p. 89 in our last issue. Reference to these curves enables us to see at once what order of brightness will cause glare at any particular illumination, and what brightness can be perceived as light immediately after one has been working in a given brightness of surroundings.

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* From a contribution to the *Journal of the Franklin Institute*, Vol. 183, No. 3, Mar., 1917.

The figure is reproduced as showing the general course of these three factors, but, as its utilisation implies converting from logarithms, it is perhaps more convenient, when only rough results are wanted, to refer to the table given in our last issue (p. 89). It was pointed out then that the glare curve gives support to the suggestion that in ordinary lighting contrasts should preferably not exceed 100 : 1. Reference to the curve shows that with 1 millilambert (approximately 1 foot-candle) glare occurs with a ratio of rather more than 1000 : 1, so that by observing the above rule we should be well within the limit. On the other hand, at 1,000 foot-candles the ratio is only 10 : 1, while, if we used an illumination much beyond this, we should be in danger of reaching a glare ratio of unity, *i.e.*, a brightness which was in itself glaring, whatever the contrast with surroundings.

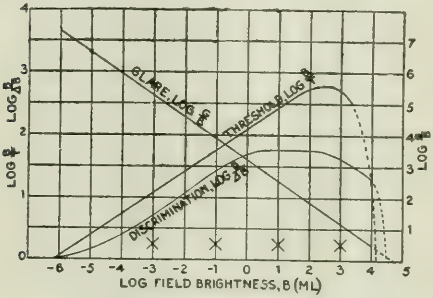

FIG. 2.—Showing general relation between field brightness and glare ratio, threshold, and discrimination.

An interesting question, apart from the contrast which produces glare, is the contrast which is most favourable to perception of detail. In the discussion on the lighting of rifle ranges before the Illuminating Engineering Society in 1915, and again in Dr. Kerr's recent paper this year, the drawbacks of excessive contrast were referred to.

But as yet this question does not seem to have been completely worked out. Mr. Nutting points out that the contrast which is sufficient to interfere with discrimination depends on the size of the central field where the variation in brightness is to be perceived. With a low luminosity diminishing the size of the field impairs sensibility, while at very bright illuminations the reverse is true.

There is some ground for believing that maximum sensibility is in general obtained with uniform brightness over the whole field of view, *i.e.*, a ratio of unity. Ives, for example, has contended that the sensibility attainable with a photometer reaches a maximum if the interior of the eyepiece is whitened and illuminated to about the same value as the photometric field. In this way, at all events, the possibility of glare is eliminated. It is to be noted that this depression of sensibility by extreme contrast is to be distinguished from the irritating effect known as glare. According to Nutting the former is a matter of total candle-power, and is not therefore relieved by a shade which merely diffuses the light. But the glare effect would be removed to a great extent by reducing the intrinsic brilliancy.

In considering the desirability of a uniform field with a view to obtaining the greatest sensibility it must be remembered that other factors come in when an interior is illuminated. For example, it would not be desirable to aim at completely uniform lighting. Although by so doing we approach a uniform field, we should practically eliminate shadows and destroy the contrast and relief on which the observation of solid objects depends. Apart from this, common experience suggests that the monotonous effect of such a system of lighting would be displeasing. In general the agreeable contrast would appear to lie somewhere between unity and 100 : 1.

RATE OF GROWTH OF SENSIBILITY OF EYE IN DARKNESS.

Another point of considerable interest is the length of time required for the eye to adapt itself to a lower order of brightness than that to which it has just been subjected. This would be useful as giving an indication how long it takes for the eye to adjust itself after coming out of a brightly lit room into the dark streets, &c.

A good test of such adaptation is the threshold sensibility which, as we have seen, is temporarily raised by exposure of the eye to great brightness.

The course of adaptation, as obtained for brightness values of 0·1, 1·0, 10, and 100 millilamberts, is shown in Fig. 3.

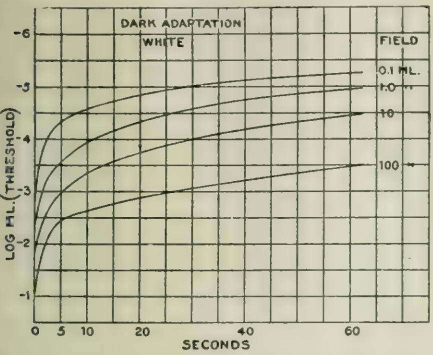

FIG. 3.—Showing time required for eye to adapt itself to perceive contrast after exposure to 0·1, 1·0, 10, and 100 millilamberts.

It will be noted that the curves in general are becoming horizontal after the comparatively short period of 60 seconds. The time of adaptation would naturally be much greater if the eye had been exposed to a brightness near the glare limit.

The following data, assembled in tabular form, are of interest :—

RATE OF INCREASE OR DECREASE OF SENSIBILITY.

	$B_0=0$, $B=25$ ml.	$B_0=25$ ml., $B=0$.
Time.	Sensibility decrease.	Sensibility increase.
1 second	2·1 times	1·6 times
2 seconds	4·3 ,,	2·6 ,,
5 ,,	16·2 ,,	7·6 ,,
10 ,,	58 ,,	14·4 ,,
10 minutes	120 ,,	20·9 ,,

The rate of adaptation also depends upon the colour. It takes place twice as rapidly for blue light as for red light, and proceeds twice as far.

It is also interesting to observe the time taken for an eye to observe *a given contrast.* A person entering a dimly lighted room, after having been in comparative brightness, sees first the objects making strong contrasts with their surroundings, and only afterwards those with moderate contrast. The fainter contrasts may fail to become perceptible after quite a long wait. Out of doors at night, not only detail in shadow, but any detail involving weak contrasts, may also fail to become visible.

APPLICATION TO PRACTICAL LIGHTING PROBLEMS.

The data obtained in these tests has a direct bearing on practical lighting problems. The object of all lighting is to secure visibility of detail in those objects to which attention is directed. This detail may be : (*a*) Mere outlines of large objects, (*b*) the outlines of small objects, as in reading, and (*c*) the minutest detail which the eye is capable of perceiving. Apart from the question of the angle subtended by the object at the eye (" fineness " of work) the amount of contrast it presents with its surroundings is a most important factor.

As examples of class (*c*) may be mentioned photo-engraving, drawing, sewing, and many other arts and crafts where critical judgment is required.

For seeing in class (*a*) but little illumination is needed. The light of a high full moon supplemented by a little local lighting may suffice. Operating so near the threshold the eye is incapable of rendering detail except with harsh contrasts. Little attention need be paid to direction of light or the ratio of direct to diffused light, since the eye inevitably operates at a low efficiency. Glare, however, should be avoided at all costs, as the eye in its state of adaptation to weak light is particularly sensitive to dazzling effects, and a relatively weakly luminous spot of light may greatly reduce sensibility, and even render objects invisible.

Seeing in class (*b*) represents the great majority of ordinary working conditions, reading, writing, and accounting coming under this head, and also the lighting of school rooms, auditoriums, &c. Contrasts in the reflecting value of objects are usually ample, and the observation of fine detail is not required.

The specification of a discrimination factor of not less than half the maximum appears reasonable. The range of brightness should, therefore, not fall below 0·1 millilamberts, and in practice values from 1—250, according to the illumination, are common. (Since in such work one rarely meets with materials that absorb more than 90 per cent. of light, a minimum illumination of one foot-candle, with a working value of two or three times this figure, should meet the requirements even of the more exacting kinds of work in this class.) The chief problem in this class of lighting is the provision of the proper ratio between direct and diffused light. Comfortable, acute vision requires that there should be neither extreme high lights nor dense shadows within the field of vision and that the details to be observed present sufficient but not too much contrast, *i.e.*, contrasts of over 50 : 49 and under 50 : 1.

With bright daylight in the open the scattered light from the sky contributes from about 16—40 per cent. of the total illumination received. On cloudy days nearly all the light is diffused. The golden mean for good average vision is probably not far from 30 per cent. diffused light.

If we view a landscape on an ordinary clear day through amber or yellow glass the view will appear very much brighter and more clean cut. The old explanation was that the yellow cuts out the purple haze, but it does a great deal more than that. It eliminates the diffuse light skylight in all shadows because these shadows are lighted mainly by blue light, leaving the directly reflected sunlight almost unaffected because the blue in it is but a small fraction of the total luminosity. The consequence is that the shadows are everywhere deepened, producing a more clear-cut effect. This greater contrast may produce what is termed a "brighter" or more lively effect notwithstanding that the total luminosity is reduced.

In the highest form of lighting (Class *c*) the minutest detail has to be critically observed, and only the very best lighting conditions will prevent visual discomfort and eyestrain. Fine needlework requires perhaps as high-class lighting as any. Interest centres on a mass of fine bright images formed by the needle and fibres of textile goods. If all the light is diffuse these images broaden and merge and shadows disappear. Vision is strained by the attempt to pick up faint contrasts just at the limit of the power of discrimination. The most suitable local lighting is that limited to nearly a single direction. What is seen is a mass of cylindrical images of the source, and if the source subtends but a small angle, these images are sharp and contrasty.

In dealing with lighting there are two extreme views: on the one hand the view of those who ignore defects and tolerate any lighting that does not cause permanent injury to the eyes; on the other the view of those who attach great importance even to minor and trivial sources of discomfort.

The true view lies intermediate between these courses. Our over-worked and much-abused eyes should be relieved from the wear and tear of the bad lighting conditions which we ourselves have put upon them. But it would be unwise and unnecessary to relieve them of all discomfort at all times, for this would surely result in a deterioration of the eye adaptability of the eye itself. Our standard should be the comfort of out-of-doors daylight lighting; abundant light, 30 per cent. diffused—and by far the most important—but moderate contrasts anywhere.

ILLUMINATING ENGINEERING AND THE CINEMA THEATRE.

In view of the attention being given to lighting problems in connection with cinematograph work by the Illuminating Engineering Society in this country, it is of interest to note that a discussion on this subject took place at a Joint Meeting of the Cleveland Section of the American Institute of Electrical Engineers, and the Pittsburgh section of the Illuminating Engineering Society (U.S.A.) on April 16th.

The discussion was opened by an address by Mr. B. Perris, of the National Carbon Co., on "Illuminating Engineering in the Motion-Picture Industry."

THE RELATION BETWEEN SUNLIGHT AND MOONLIGHT.

By J. S. Dow.

Much work has been done on the photometry of daylight during the last few years, but the writer cannot recall a recent attempt to relate photometrically the intensities of sunlight and moonlight.

Astronomically the problem is of some interest as furnishing a rough check on the distance of the moon from the earth, and as a verification of the fact that moonlight is merely due to reflection of the sun's rays. Owing to the number of variable or unknown factors, one cannot expect any great precision in such a calculation. The object is to show that the value of full moonlight illumination can be roughly predicted from the measured value of direct sunlight. It is sufficient for our purposes if the calculated value of moonlight is found to be *of the same order* as that actually measured.

The diameter of the moon is approximately 2,160 miles, its distance from earth approximately 240,000 miles. The distance of the sun from the earth (approximately 93 million miles) is sufficiently great for us to assume that this is also its distance from the moon. The error in this assumption is within one per cent. On this understanding the actual distance of the sun need not enter into the calculation.

The starting point in our calculation is the value of the illumination (on a surface perpendicular to the sun's rays) derived from full sunlight with an unclouded sky. This value is variable according to the period of the year and the locality, but in England probably reaches a value with an unclouded summer sky of about 10,000 ft.-candles.

The illumination received by the moon should therefore be of about the same value but for the fact that the moon has no atmosphere and the sun's rays do not suffer the resulting absorption as in the case of rays reaching the earth. But if we remember that the light from the moon has likewise to pass through the earth's atmosphere in reaching this planet, it seems justifiable to ignore this absorption, which may be regarded as cancelling out.

Let us assume, therefore, that the illumination on the moon's surface also reaches 10,000 ft.-candles. Our next step is to calculate the approximate brightness and candle-power of the moon. If the moon's surface had a reflecting power of 100%, its brightness would be $10,000/\pi$ candles per square foot. Naturally we do not know enough of the moon's surface to determine its average reflecting power. It is believed, however, to consist mainly of volcanic rock, whose reflecting power would probably not exceed 20 per cent. A rough check on this value is obtained by determining the apparent surface-brightness of the moon by a direct measurement through the Lumeter or other suitable photometer. Nutting has given this value at about 1,000 ft.-candles. The author's measurements of the clear full moon on a clear night have given somewhat lower values. (In this determination we again ignore the factor of atmospheric absorption, but this, as explained above, may be regarded as eliminated owing to a similar error having been made in the estimate of the illumination received by the moon.)

We shall probably be within the limit by taking the surface-brightness of the moon as 1,000 ft.-candles, or $1,000/\pi$, candles per square foot. This figure is not unreasonable when we recall that, apart from the probably low reflecting power of the moon's surface, the surface will not obey Lambert's law exactly, and, being spherical, will allow a certain portion of the rays to glance off obliquely in direct reflection.

Since we have started from the illumination perpendicular to the sun's rays, we must next take the projected area of the moon which is

$$\frac{\pi\times(2160\times5280)^2}{4} \text{ square feet.}$$

The approximate "apparent" candle-power of the moon is therefore :—

$$\frac{1000\times\pi\times(2160\times5280)^2}{\pi\times4}$$

and the illumination produced at the earth's surface (again perpendicular to the direction of the moon's rays) at full moon, with a clear sky, and with the moon at its zenith, should be about :—

$$\frac{1000}{\pi}\times\frac{\pi\times(2160\times5280)^2}{4\times(240{,}000\times5280)^2}=$$

0·02 ft.-candle approx.

Actual measurements made by the author under the above conditions give about 0·015—0·025 ft.-candle, which, considering the many variable and unknown quantities, is remarkably near the calculated figure.

The above calculation is only given as a rough indication of how moonlight and sunlight may be related photometrically. By taking special precautions to allow for the altitude of the sun and moon at which measurements are made (and the resulting depth of atmosphere through which the rays penetrate) and by endeavouring to secure identical atmospheric conditions in both cases, a more exact result might be obtained.

It is interesting to note that the range of illumination between moonlight and sunlight, about 1 to 500,000, corresponds with well-defined limits in the state of adaptation of the eye. The lower limit is about the value where colour-discrimination is getting difficult, and where the Purkinje effect becomes very pronounced—where, in fact, "dark-adaptation" has well set in. The higher limit, according to Nutting, is approaching the brightness value to which the eye cannot adapt itself—the limit of absolute glare.

AWARDS OF THE AMERICAN MUSEUM OF SAFETY.

Four out of the five gold medals awarded annually by the American Museum of Safety have now been made public. The Anthony N. Brady Memorial Medal, awarded to the electric railway company which in the year of the award has done most to preserve the safety and health of the public and its employees, has been awarded to the Connecticut Company.

The Scientific American Medal, awarded for the most efficient safety device invented within a certain period of years and exhibited at the Museum, goes to the Pullman Company for the Dean end frame for passenger cars.

The Traveller's Insurance Company's Medal, awarded to the American employer who has rendered striking services in protection of life and limb of workers, goes to the Commonwealth Steel Company of St. Louis.

The Louis Livingston Seaman Medal, awarded for progress and achievement in the promotion of hygiene and the mitigation of industrial diseases is awarded to the Julius King Optical Company of New York, in recognition of its scientific investigation of the effect of coloured glasses to be worn by workmen whose eyes are exposed to the blinding glare of molten metal, oxy-acetylene and electric arc welding, &c. The glass recommended is designed to check the ultra-violet rays without unduly impairing the transmission of visible light.

SOME PROPERTIES AND APPLICATIONS OF SELENIUM.*

By E. E. Fournier D'Albe.

The application of selenium to photometric problems was proposed many years ago. It has long been known that this substance is affected by light, its resistance diminishing considerably under the influence of illumination, though the rays which produce the most powerful effect are not necessarily those to which the eye is most sensitive.

This property of resistance to light was discovered by Willoughby Smith in 1873. Selenium cells are made up of deposits of selenium in the form of grid or spiral, the aim being to present as large a surface as possible to the light and to diminish the resistance to a convenient figure by giving the conducting surface a very large sectional area but a relatively small length. In the construction of such cells Mr. Fournier d'Albe uses a porcelain plate, coated with graphite in which grooves are engraved by means of a diamond. The whole surface is then covered with selenium, which must be prepared specially so as to have the requisite sensitiveness to light.

Such cells have been used to measure the light from distant stars. Minchin succeeded in this way in measuring the brightness of the Jupiter, Venus and Capella, but, according to Mr. Fournier d'Albe, it is possible, by using a suitable telescope, to discover stars of even the seventeenth magnitude. It is possible to use currents even below 10^{-11} amp. With the naked eye one can just detect stars of the sixth magnitude, whereas with selenium one should be able to detect stars of the ninth magnitude. By the aid of a telescope, used in conjunction with selenium, it might be possible to locate stars which are absolutely undiscernible through the eye.

Clearly, if in selenium we have a means of revealing light too faint for the eye to perceive, this is in itself a most important result.

The chief difficulty in using selenium for photometry is the time necessary for the recovery of the material after exposure. One must use comparative methods. One may, for example, place the cell between the sources of light to be compared and rotate it, and then note whether any dissymetry is observable in passing from one source to the other. Apart from this, selenium, as is well known, is "colour-blind" to some extent, there being strong reaction or resonance in the extreme red. One can also obtain reaction from the infra-red rays and, to a limited extent, from the ultra-violet.

The application of selenium to the working of automatic shutters in a camera has been suggested. If this were practicable we should never have to trouble about exposure, the selenium acting as a perfect control. But the advantages so gained would be outweighed by the inconvenience of introducing relays.

By the use of flashes of light, acting by a siren-disc arrangement at regular periods on selenium, thereby making a musical scale, a form of multiple telegraphy might be developed. By such a system it would be possible to send a number of different messages along the same wire. By means of the photographone sounds can be caused to give rise to corresponding alterations in the light from an electric arc ; this in turn, by reacting on selenium, might be made to reproduce sounds. In Italy the photographone has been applied to the problem of producing sounds in exact synchronism with the movements of actors in a cinematograph display.

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* Abstracted from the *Journal of the Röntgen Society*, April, 1917.

Phototelegraphy, the transmission of pictures along a wire by the use of selenium, has been carried to quite a practical stage. This was first done by Shelford Bidwell and subsequently developed by Korn, who transmitted pictures by dividing them into strips and sending each strip to the receiving apparatus at the other end of the line. Selenium, however, has been largely replaced by swelled gelatine for this purpose. Such a development almost brings within sight of practical achievement the dream of "television"—the seeing of distant objects through the medium of a wire. If one could transmit pictures with sufficient speed along a wire this might become feasible.

Among other interesting applications may be mentioned the use of selenium to control the lighting of buoys and lighthouses, the wireless selenium telegraphy invented by Graham Bell, and Bell's "photophone," by which intermittent light falling on selenium is made to set up a sound in a telephone.

The idea is somewhat differently developed in Mr. Fournier d'Albe's "optophone," a device intended to facilitate reading of type by ear, which may be of service to the blind. By arranging a scale of frequencies to denote various letters, and by exciting these timed vibrations by the transmission of light through transparent letters, it is possible to identify each letter by the sound.

An important matter, affecting some uses of selenium, was referred to by Mr. Thorne Baker in the course of the discussion—namely, the effect of the atmosphere upon selenium. The variation of atmospheric conditions in Paris, London, and Manchester, for example, on any given day, would give rise to quite different results. This was a difficulty that required to be overcome in the transmission of pictures by selenium.

SELENIUM CELLS OF GREAT SENSITIVENESS.

THE *Electrical World* for April 23rd records an interesting claim for the improvement of selenium cells. According to a patent, No. 1,219,432, F. C. Brown has succeeded in making cells with a sensitiveness a thousand times greater than those hitherto constructed. This result is accomplished by the production of the crystals by sublimation, and the crystals being allowed to absorb argon, helium or neon gas at a temperature below that of the crystal-formation. Both large crystals and those of microscopic size were studied. It is claimed that after being exposed to most intense light twenty-four hours a day for thirty-five days in succession, the crystals showed no appreciable deterioration, and one cell, when subject to ordinary conditions of use, was found to possess the same sensibility after a period of a year.

GOOD ILLUMINATION—AN ASSET TO SUPPLY COMPANIES

In a recent article in the *Electrical World*, Mr. C. E. Clewell narrates a most interesting episode in the lighting of an American city, showing the results of insufficient education of the consumer in the use of his light to the best advantage.

The trouble arose in the borough of Catasauqua, where, in May, 1915, Mr. C. E. Clewell was asked to make an exhaustive enquiry into the grounds of public dissatisfaction with the lighting arrangements. It is stated that the circumstances in this case were unusual, no difficulty having been raised in the remaining 98 per cent. of area served by the same company, but nevertheless Mr. Clewell's comments would doubtless have a bearing on conditions in many cities—and not only in the United States.

Shortly before 1915 the old privately owned plant was bought up by the Lehigh Valley Light and Power Co., a concern which supplies twenty or more municipalities in the State of Pennsylvania. The company immediately set about a reform in many directions. Antiquated meters and lax methods of rendering and collecting accounts were improved and at the same time the consumers were promised better light and cheaper service.

Nevertheless, in spite of the general introduction of metal filament lamps (instead of carbon filament lamps which had been generally used prior to that time), the consumers continued to complain of unsatisfactory lighting conditions and higher bills. In the latter respect the Company was apparently reaping the result of the lax methods of charging and collecting prevalent before they took the business over. But when Mr. Clewell undertook a survey in 1915, a number of circumstances unfavourable to good illumination were revealed. For example, while graphic records showed a fair constancy in the voltage at the sub-stations, considerable variations at the consumers' premises, due to the inadequate distribution arrangements of the old company, were found to exist.

An equally important circumstance was the neglect of proper lighting appliances and methods of applying the light provided. Bare lamps without any well-designed reflectors were usual, and it is not surprising that in the circumstances fault was found with the illumination, although in many cases it was the consumers' neglect to use suitable lighting shades and reflectors that caused the trouble.

As a result of his investigation Mr. Clewell made a number of suggestions, essentially all of which were accepted and strenuously undertaken by the Company during the two years that followed.

The defects to which Mr. Clewell drew attention were substantially as follows :—

(1) Indicated voltage in residences showed considerable variations from standard value. Distribution circuits probably at fault.

(2) Voltage rating of lamps employed shows wide variations.

(3) General use of bare lamps for residence lighting.

(4) Education of consumers in the use of proper shades and reflectors should be started.

(5) Consumers should be told that lighting is best judged by the way objects to be seen are illuminated and not by the glare from the lamps.

(6) Consumers are in general using lamps of larger size than is necessary. Smaller lamps with suitable reflectors may actually result in improved illumination.

(7) Discourage the use of clear glass reflectors.

(8) Rearrange distribution circuits so as to supply some standard voltage to all residences.

(9) Standardise on some definite lamp voltage.

Practically all these recommendations were adopted by the Company. Besides making good technical defects canvassers were engaged to instruct the consumers and deal with complaints. Nevertheless, the lost ground could not be made up and eventually a demand was lodged for the supply to be taken over by the municipality.

At the hearing there was very general belief expressed that the bills were higher than formerly and the service less satisfactory. Many of the complaints were clearly absurd and showed marked lack of knowledge of illumination on the part of consumers. Thus one witness, when asked if he used reflectors with his lamps, said, "No, I never use reflectors or shades; I find that the light is worse with reflectors than without them." Yet the actual conditions in the hotel referred to were about as bad from the lighting standpoint as they could possibly be.

The incident is interesting as showing how "public service" is coming to be associated with the supply of gas and electricity. To leave the consumers in a state of ignorance on illumination is to court disaster. At an early stage their sympathy must be sought, and much patience must be exercised in gaining their confidence and in leading them to believe in the advice given. In this case the Company, in spite of their belated efforts, failed to make good the lost ground, one circumstance which told against them being that while the accuracy or inaccuracy of statements regarding bills was readily checked they were less ready to formulate immediate answers to charges of bad lighting.

It is essential nowadays not only for a company to cultivate the confidence of consumers and study their requirements from the start, but also to maintain a staff of experts trained to understand lighting problems and able to give the best advice. It is often no easy matter to put things right when suspicion and animosity have once been excited.

The whole question deserves very careful consideration by supply companies in this country, especially at the present time. During the war companies have been faced by special problems. On the one hand, there has been a tendency to raise rates, on the other, difficulties in paying close attention to consumers' needs, owing to shortage of staff.

Nevertheless, companies would be well advised to keep their machinery for personal contact with consumers complete, and even to make more assiduous efforts in this direction. The effect of the illuminating engineering movement has been already to make the public more discriminating in regard to lighting matters. Supply companies, on their part, would derive much benefit from a more intimate connection with the movement, and by taking a more active part in the education of the public in regard to illumination.

SHORT NOTES
ON
ILLUMINATING ENGINEERING.

HOW TO SECURE EFFICIENT AND ECONOMICAL LIGHTING.

According to the *Electrical Review and Western Electrician*, a bulletin has been issued by the Sealer of Weights and Measures in Massachusetts, containing some popular information on the use of electricity, and the possibilities of avoiding waste.

The Commissioner states that meters are often blamed for bills that seem unduly high. In reality defects in meters are rarely responsible for high bills, the chief causes of which are: (1) Dark weather, (2) additional lamps installed or lamps of higher power, (3) the use of dim or obsolete lamps which should be replaced by new ones, *e.g.*, carbon filament lamps instead of tungsten lamps, (4) lamps left burning in closets, attics, &c., (5) laundry irons, toasters, or other appliances used to an exceptional extent, (6) defective wiring, (7) machinery that is not properly oiled, and (8) errors in meter-reading.

CALORIFIC VALUE OF GAS PROPOSED IN THE UNITED STATES.

In a recent paper entitled " Some Notes on Gas Standards " before the Illuminating Engineering Society (U.S.A.), Mr. W. R. Addicks emphasised the growing importance now being attached to a calorific standard for gas. In the year 1915 Canada adopted substantially the same standard as Great Britain in this respect.

At the last annual meeting of the American Gas Institute the following resolutions were adopted :—

Resolved : That the total heating value in manufactured gas best represents its quality for standard requirements ; and

Further resolved : That the American Gas Institute recommends the adoption of the total heating value as the only standard basis of rating the quality of all manufactured gas distributed in the United States.

LIGHTING THAT FITS NIGHT WORK.

The March issue of *System* contains an article by Mr. L. Gaster under the above title. Illustrations of typical factory installations are reproduced and the chief arguments in favour of good lighting from the economic and hygienic standpoints are summarised.

Figures are quoted to show that the cost of lighting in general forms but a small fraction of the wages bill. For example, it is calculated that in the case of skilled labour the running cost of the lighting provided per man during a normal day's work is roughly equal to the amount paid to him in wages during only three minutes of his time. If, therefore, as a result of better illumination the worker was able to save only three minutes on his job, this alone would cover the lighting expenditure.

MORE EXAMPLES OF FLOODLIGHTING.

Some time ago we described the floodlighting of the Statue of Liberty in New York Harbour We note that the same method was used to illuminate the Capitol Building in Washington on the occasion of the inauguration of President Wilson on March 5th.

The subject of floodlighting is to be discussed in two forthcoming papers before the Illuminating Engineering Society, U S.A. Its use for outside illumination of public buildings has received official recognition in the United States, and in the future the possibilities of the system will have to be considered by lighting engineers in this country.

Recent issues of the *Electrical World* contain some account of the application of this system of lighting for purely utilitarian purposes. For example, at Greensboro' (N.C.) a sub-station of the Southern Power Co. makes use of a lamp in an automobile reflector for lighting a number of oil switches. This section was built without ceiling or wall lights, and numerous leads from them make the placing of lamps in the vicinity inconvenient. Accordingly the flood-light has been installed to enable the switches to be observed from a distance. The unit can be turned in any direction so as to strongly illuminate any object that requires attention.

Another interesting development is reported from New York city, where the central station companies are now arranging to flood-light all the bridges over the East River.

Projectors have been placed under the arches of the bridges, along the waterway, and round the stone piers, to enable the river to be easily surveyed and closely guarded. Danger signs to keep boats away from the bridges have also been posted and illuminated.

LIGHTING A SWIMMING BATH WITH SUBMERGED LIGHTS.

Submerged lighting of a swimming bath is being installed at Seattle, Washington, large specially designed waterproof automobile headlights being employed. Fifteen such units have been installed at intervals of 10 feet.

This novel method of lighting is said to have been very effective, and deserves attention in the interests of safety.

SAFETY FIRST AND THE RULE OF THE ROAD.

The London "Safety First" Council proposes to issue a series of leaflets indicating measures to be taken in the interest of safety. Leaflet No. 1 deals with "Hints to Drivers of Horsed and Motor Vehicles and to Cyclists." Concise directions are given as to hand signals indicating the intended movements of the vehicle, coming out of side streets or yards, front and rear lights after sunset, &c.

The following rule is an ingenious statement of the "Rule of the Road," a rhyme deserving to be remembered :—

"The Rule of the Road is a paradox quite,
In Riding or Driving along,
If you keep to the **Left** you are sure to be *right*,
But if you go **Right**, you are *wrong*.

Copies can be obtained from the Hon. Secretaries of the London Safety First Council, 31, Westminster Broadway, S.W.1.

DETECTION OF FOREIGN METAL BODIES BY RONTGEN RAYS.

As is well known, Röntgen rays provide one of the most effective means of locating foreign objects in the human body, and have been extensively used for detecting splinters of shell, &c., since the war began.

In a recent number of the *Journal de Physique*, several devices for obtaining greater precision are described. These are of interest as showing how the course of these rays can be traced in much the same way as rays of light.

For example, a form of tube with two separate and distinct discharge points is now used. These are focussed on the point where the body is expected to lie and by tracing, by the images on the fluorescent screen, the course of the cross-rays from the two sources the position of the body can be exactly determined. Another method is based on observation of the exact points at back and front of the body where the ray enters and departs. The line connecting these points will then pass through the embedded object.

THE PRODUCTION OF LIGHT BY ANIMALS.

A comprehensive paper describing the organs of a variety of insects and animals capable of giving off light in the dark is being contributed by Professor Ulrich Dahlgren to the *Journal of the Franklin Institute.* Many interesting observations on the conditions affecting the production of luminosity are made. There seems to be an extraordinary variety of luminescent insects in different parts of the world and, as is well known, the degree of luminosity produced is in some cases by no means inconsiderable. Mr. F. H. Glew has stated at a recent meeting of the Illuminating Engineering Society that the light of a glow-worm has about the same luminosity as 74 milligramme radium zinc sulphide composition—a strength much, very much, higher than that ordinarily employed, which would probably give a surface brightness approaching half a foot-candle.

Professor Dahlgren states that many luminescent creatures when out hunting their prey have a habit of turning the light on and allowing it to glow for minutes at a time. Whether this is due to the need for a recuperative pause or the deliberate economy on the part of the creature in only turning on the light when it is needed is not stated. In some cases the light is brought into action whenever the creature is disturbed or roughly handled, but gradually subsides when it is left alone.

It is interesting to note that the larvæ during development also exhibit the characteristic glow; in fact, their development can be traced by the waxing and waning of the "larval lights." Just before hatching they light up all over, but do not flash, slowly lighting and darkening.

Professor Dahlgren's researches deal chiefly with the biological side of these phenomena. We should very much like to see a corresponding inquiry into the chemistry of luminescent animals, which might yield some useful hints for practical development.

A COLOUR-SCHEME TO PREVENT CONFUSION OF PIPES.

According to *Popular Mechanics,* a very complicated system of piping, as much as 50 miles in length, and conveying no less than twenty-one different liquids and gases, is used in the Massachusetts Institute of Technology. In order to prevent confusion, it has been found necessary to paint the pipes with different colours so as to indicate their contents. Otherwise there might be some danger, for example, of a person tapping an ammonia pipe when in want of gas or water.

In the large mechanical engineering laboratory the pipes are painted their entire length in characteristic colours. Elsewhere the prevailing colour is white, with light patches of distinguishing colours at intervals. Pipes for water from the Charles River are painted emerald green; for the Cambridge domestic water supply blue, and for the filtered drinking water light yellow. Other colours used are drab for compressed air, black and white for high pressure steam, with another colour at the joints; ultramarine for brine pipes and light green for sulphuretted hydrogen pipes.

INDIRECT GAS LIGHTING IN A CHURCH.

Last year we described the interesting semi-indirect gas lighting installation in the Cathedral of St. Peter and St. Paul, Philadelphia. We notice in the *Gas Age* an account of a similar method of lighting in the Zion Church in Washington.

The fixtures carried 18-inch diffusing glass bowls, equipped with five-mantle burners, the fixtures being hung at a height of 16 ft. 10 in. There is also special lighting in the choir loft, the upper and lower balconies and the side aisles, ribbed white opal globes being here employed.

The installation is illustrative of the tendency towards diffused subdued illumination for churches. It is evidently becoming widely recognised that the leading requirement in such cases is elimination of glare.

CO-OPERATION BETWEEN ENGINEERING SOCIETIES IN THE UNITED STATES.

As is well known, the chief engineering and scientific societies in the United States have for some time been considering methods of taking combined action in matters of common interest.

In the United Engineering Societies building they have already the advantage of a joint meeting place. According to the *Electrical World*, a movement is now on foot to form a United Engineering Societies Council for the purpose of collective utterance and action. In the Conjoint Board of Scientific Societies in this country we have a similar attempt at concerted effort, which in the interests of science and engineering is greatly needed.

A NATIONAL RESEARCH INSTITUTE IN JAPAN.

We notice in the *Electrotechnische Zeitschrift* a reference to the National Research Institute (Rikagaku Kenkyusho) to be established in Japan, which, it appears, was already on the way to completion in 1916.

The field of study for the Institution, for which two million yen has been allotted, is very comprehensive, including many chemical and electro-chemical investigations and such problems as the production of nitrogen from the atmosphere, investigations of steel and metal, and the study of the resources of Japan and its colonial possessions.

It is interesting to note that illumination is one of the subjects specified for study.

MEDICAL CERTIFICATE FOR MUNITIONS WORKERS.

Memorandum No. 16, issued by the Health of Munitions Workers' Committee, deals with medical certificates for munitions workers. It has been found hitherto that certificates have sometimes been made up on odd scraps of paper and do not show the address of the medical officer and other desirable information. In addition, it was sometimes not clear whether the indisposition was slight or temporary merely, or whether it necessitated absence of the worker even from urgent jobs. The Committee therefore present in this memorandum a model form of certificate. It is hoped that the general adoption of this certificate will meet many difficulties at present experienced in dealing with absences of munitions workers on account of illness, and will also provide a basis for the collection of valuable data as to the incidence of different types of illness and as to periods of absence involved

VISUAL DIFFUSIVITY.

A contribution under the above heading by Dr. H. E. Ives in the *Philosophical Magazine* describes some interesting experiments with sector discs, showing the "recurrent image." If discs of progressively increasing diameter are fitted one behind the other, and thin radial slots are cut in each and illuminated from behind, some curious effects are obtained when the discs are rotated.

For example, if one slot is less bright than the other then it appears to lag behind when the discs are rotated. Similarly if three slots are illuminated respectively with red, green, and blue light, the red slot appears to be in advance of the other two colours, the blue slot being most retarded. By adjusting the displacement between the discs the angle of lag can be measured.

Another effect is the appearance, at weak lights, of a ghostly image following the blue slot at a constant distance behind. This does not occur with red light at all, while at strong illumination the two images gradually approach and coalesce. This retardation and recurrent image Mr. Ives endeavours to explain by a special theory of vision, which assumes that the transmission of impressions to the brain is in accordance with the physical laws of conduction, the diffusivity being different for various colours. Further confirmatory evidence is afforded by the close resemblance between the curve of sensation for the eye, exhibiting an after-image, and the corresponding curve for a short contact transmitted by an electrical transmission line containing both inductance and capacity.

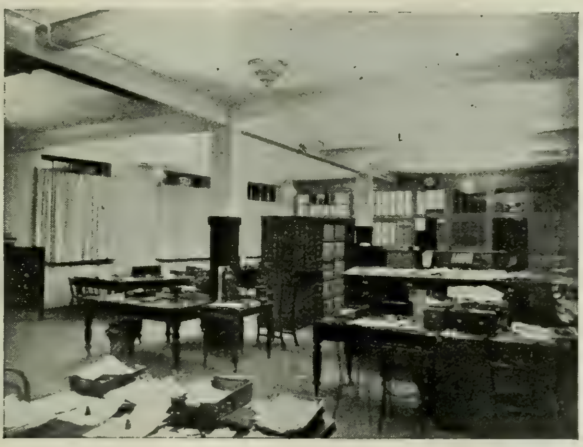
LIGHT AS AN AID TO RECRUITING.

The suggestion is being made in the United States that attractively lighted windows should be devoted to exhibitions for recruiting for the Navy. The *Electrical World* for March 24th illustrates a well-designed concealed lighting exhibit of this type.

TOPICAL AND INDUSTRIAL SECTION.

[At the request of many of our readers we have extended the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]



Part of the General Offices of the Lodge Sparking Plug Co., lighted with "Eye-Rest" Indirect System.

TO GAS ENGINEERS.

Offer of Photometric Equipment.

To Gas Engineers, Lighting Experts, etc.

Offer wanted for:—Photometric equipment, consisting of Radial Mirror arrangement, Photometer Bar, with 3 Carriers and 3 Shades, Bunsen Disc Box, Simmance-Abady Flicker Photometer, Standard Electric Lamps with N.P.L. Certificates. Rheostat Low Pressure Meter, High Pressure Meter-table; also Harcourt 10-candlepower Lamp and Pediment Barometer, all complete. Address, Z.L., 669, c/o Deacon's, Leadenhall Street, E.C.3.

WORKS LIGHTING.

The above is an illustration of the lighting of the General Offices of the Lodge Sparking Plug Co. with indirect lighting.

In the other sections of the Company's premises different methods are employed according to the nature of the work. For example, for the lighting of tools for small size repetition work localised general lighting with "half-watt" Mazda lamps in Mazdalux reflectors is used.

The equipment, which was installed by the British Thomson-Houston Co., Ltd., Rugby, is thus typical of the varied requirements of a modern factory.

THE TECHNICAL COMMITTEE OF THE MOTOR INDUSTRIES.

We observe that a new Technical Committee, to be known as the Technical Committee of the Motor Industries, has been formed by the Institution of Automobile Engineers and the Society of Motor Manufacturers and Traders in order to co-ordinate the many technical questions which arise in connection with the automobile industry.

The Committee will be strengthened by the addition of representatives nominated by the various Government Departments and Institutions, and is to receive recognition under the Department of Scientific and Industrial Research. Invitations to be represented on the Committee have already been accepted by the National Physical Laboratory, the General Post Office, the Institution of Mechanical Engineers, the Iron and Steel Institute, and the Commercial Motor Users' Association. It is hoped that the formation of the new Committee will be helpful in preventing overlapping, and by bringing about concerted efforts on the part of the various institutions concerned.

Further information may be obtained from the Joint Secretaries, Mr. Basil H. Joy, The Institution of Automobile Engineers, 28, Victoria Street, S.W.1, or Mr. T. F. Woodfine, The Society of Motor Manufacturers and Traders, 83, Pall Mall, S.W.1.

PERSONAL.

Dr. James Kerr, who is associated with the Education Department of the London County Council, and is well known to readers of this journal as a prominent member of the Illuminating Engineering Society, has accepted a Commission as Major in the R.A.M.C.

We understand that Dr. Kerr has taken up his new duties and we wish him every success in his new position.

Dr. Rene Sand, who, after the invasion of Belgium, came to this country, where he has until recently been employed on physiological work, is now attached to the Ambulance de l'Ocean, La Panne, with the Belgian Army.

Dr. Sand has sent us a little publication which he has drafted, entitled "La Médecine sociale en Angleterre," wherein he describes, in sympathetic terms, some of his experiences in England, referring particularly to the widespread voluntary service in regard to social and hygienic matters.

STUDENT CAPTIVES.

A little booklet, issued under the above title, has been written by Mr. Alfred T. Davies, Chairman of the Committee of the British Prisoners of War Scheme (Board of Education).

The object of the scheme is to help prisoners of war by providing them with technical and educational literature, and to enable them to continue their education even under the distressing conditions of captivity. Under the scheme suitable books are regularly sent to prisoners' camps, and it has even been found possible, by the co-operation of the Censor, to conduct examinations from the outside world.

In the national interest it is vital that everything possible should be done to fill this gap, and to provide the intellectual food without which captivity becomes unendurable.

All those who have books of technical, scientific, or educational value which they are willing to place at the disposal of the British Prisoners of War Scheme should communicate with Mr. Davies at the Board of Education. In this direction most of us could do a little to alleviate the suffering caused by the war, and we feel sure that the appeal will evoke an immediate response.

Assets exceed £2,500,000.

Claims paid over £8,500,000.

By Appointment.

GENERAL
Accident Fire and Life
ASSURANCE CORPORATION, Ltd.
General Buildings, Perth, Scotland.
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WAR ECONOMY.

In consequence of the War, the cost of building material and labour has increased nearly 50 per cent. All owners of property should therefore increase their Fire Insurances; this they can do at little or no extra cost by taking a Fire Bonus Policy with this Corporation, and thus effect a saving of 20 per cent. of each premium.

Particulars on receipt of post card at either of the above Offices.

F. NORIE-MILLER, J.P.
General Manager.

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COUPON INSURANCE TICKET

Applicable only within the United Kingdom.

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ACCIDENT FIRE AND LIFE
ASSURANCE CORPORATION, LTD.,
Chief Offices—
GENERAL BUILDINGS, PERTH, SCOTLAND.
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F. NORIE-MILLER, J.P., General Manager,

To whom Notice of Claims under the following conditions must be sent within seven days of accident.

£250 TWO HUNDRED AND FIFTY POUNDS will be paid by the above Corporation to the legal personal representatives of any person who is killed by an accident causing material damage to the passenger train in which the deceased was travelling as a ticket bearing or paying passenger, or who shall have been fatally injured thereby, should death result within one calendar month after such accident. **Provided** that the person so killed or injured had upon his or her person, or had left at home this coupon, with his or her usual signature, written prior to the accident, in the space provided below, which, together with the giving of notice within seven days to the above Corporation is the essence of this contract.

This Insurance only applies to persons over 14 and under 65 years of age, is subject to the conditions stated above and contained in the General Accident Fire and Life Assurance Corporation Act, 1907, and holds good for the current month of issue only.

No person can recover under more than one Coupon Ticket in respect of the same risk.

Signature ....

This Coupon must not be cut out but left intact in THE ILLUMINATING ENGINEER as that, being dated, forms the only evidence of its currency.

USE GAS AND SAVE COAL.

A recent statement issued by the Ministry of Munitions refers to the desirability of economising in coal by using gas or coke wherever possible. In this way the valuable by-products recovered in the production of gas from coal are preserved and the waste inevitable in the ordinary coal fire is avoided.

It is stated that efforts are now being made to place adequate supplies of coke at the disposal of the public.

BUSES RUN WITH GAS.

Much interest has been taken in experiments that are being made with a view to the use of gas in internal combustion motors on lorries, &c. The gas is readily stored by compression, and we understand that promising results are already being obtained.

In the *Gas World* reference was recently made to the experience of the Grimsby Tramways Co., where a bus worked in this way has been running quite satisfactorily. The bag contains about 500 cubic feet of gas, which is ample for a double journey, and the gas is used with the motor previously used for petrol.

THE SOCIETY OF BRITISH GAS INDUSTRIES.

At the annual meeting of the Society of British Gas Industries, on April 17th, an address was given by the President, Sir Robert Hadfield, dealing chiefly with Patent Laws, while Mr. H. A. Bennie Gray discussed "The Education and Training of Engineering Apprentices."

Mr. Gray pointed out the absurdity of expecting apprentices to attend night classes after an exhausting day in the shops. Provision should be made for their education during working hours. An interesting departure in this direction has been made in Huddersfield, where the engineering employers decided to equip, at their own expense, an up-to-date engineering department at the local technical college for the use of pupils The progress of each apprentice was closely followed, and opportunities were provided, in the form of scholarships, for the most gifted to continue in more advanced courses.

The results of this step had already been most satisfactory. It was expected that in future, as a result of such training, the output of engineering works would be considerably increased, even though the working week was diminished to fifty-four hours.

THE APPLICATION OF COAL GAS IN WAR INDUSTRIES.

Lecturing before the Royal Society of Arts on April 18th, Mr. H. M. Thornton gave some interesting details of the uses of gas in munitions work, notably in the form of furnaces employed in dealing with large guns, rifle barrels, &c., and the treatment of high speed steel. A remarkable fact had been the increase in gas consumption since the outbreak of war, tables for leading gas companies showing advances of 28, 57, 64, 72, 84, 100, 112, and 154 per cent. Of great importance, also, was the use of gas in welfare work, in canteens, swimming baths, gymnasia, &c.

Finally, Mr. Thornton referred to the many special uses being discovered for derivatives in coal gas manufacture. It was quite possible that in the future gas might itself become a "by-product," and the materials now classed as by-products might become the chief items in manufacture.

ELECTRICITY · ACETYLENE

The ILLUMINATING ENGINEER

OIL · GAS

Edited by LEON GASTER

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EDITORIAL.

Economy in Lighting in Relation to Fuel-Saving.

The discussion on the above subject at the Annual Meeting of the Illuminating Engineering Society on May 15th (see pp. 131-136) was very timely. Now that the summer months are with us it is a fitting time to consider what steps may be necessary before the dark days of winter, when artificial lighting is mainly required.

The first point to establish is the extent of the fuel saving that may reasonably be expected to follow from judicious restrictions in lighting. From the figures presented before the Committee on the Summer Time Act (1916) it would appear that gas and electric supply companies consume for lighting purposes only about 2½ per cent. of the entire coal supply. Consequently, even if we were able to bring about a general saving of 10 per cent., the corresponding diminution in fuel used would not exceed a quarter of one per cent. The most fruitful field for economy, as suggested by Mr. Faraday Proctor and Mr. Crowley, lies in the more efficient use of our coal for power production, especially in view of the fact that our industrial future will doubtless demand the utilisation of power to a greater degree than at present.

Nevertheless there are good reasons for desiring the elimination of waste of light—a thing which the Society has always condemned as objectionable even in time of peace, and especially so in the present circumstances. It must be remembered that the amount of coal available for lighting purposes is necessarily limited at present, not only because of the shortage of coal, but also because of the greatly increased demands on gas and electric supply companies for power purposes. In some districts it is common knowledge that companies find a difficulty in coping with this demand and would therefore welcome any diminution in luxury lighting, especially at the peak time of the load. The avoidance of waste of light has also a moral justification, because members of the general public, noting the lavish use of light for spectacular purposes, but not knowing how small the fuel so consumed is in relation to the total consumption, might jump to the conclusion that the shortage of fuel had been exaggerated.

For these reasons judicious economy in lighting would be welcome. It should, however, be secured in a scientific and well-considered way. It is now generally agreed that an indiscriminate diminution of, say, 10 per cent. would not be desirable. Light is not a luxury but an essential commodity for industrial and manufacturing processes ; it would clearly be bad policy, at a time like the present when every factory is working at high pressure, to risk a diminution in output or impairment of quality through insufficient light. It was therefore suggested that any compulsory diminution in lighting should apply, *first*, to luxury and spectacular lighting, *second* (and only in extreme emergency), to lighting desirable in the interests of public convenience, but in no case to industrial and munitions works, nor in circumstances where it is necessary to public safety. The division of the existing lighting into these respective categories, with due consideration of the needs of each district, would obviously require a considerable amount of technical experience, and it was suggested that the matter might be considered during the summer months by a Joint Committee, on which the Illuminating Engineering Society should be represented.

Meantime it is of interest to note that the Authorities have already proceeded in the direction indicated in this discussion. Only a week after the Annual Meeting an Order was issued (see p. 148) prohibiting the use of lights for outdoor display, street-signs, &c. There is little doubt that in the present darkened condition of the streets the exhibition of such powerful lights is undesirable from the standpoint of public convenience and safety, as well as being wasteful, and we hope that even after the war is over there will be a thorough revision of methods of outside lighting.

Industrial Research in the United States of America.

We have received a copy of an interesting report on the above subject by Mr. A. P. M. Fleming, the first of a series to be issued by the Department of Scientific and Industrial Research. The Department are to be congratulated on their initiation of this useful piece of work, and we are confident that the periodical issue of information of this character will be very helpful in guiding public opinion in the right direction. We hope to give a fuller account of Mr. Fleming's report in our next issue, but meantime would like to refer to some of its leading features.

The industrial researches described by Mr. Fleming are classified according to whether they are undertaken by manufacturing corporations, associations of manufacturers, universities and colleges, national institutions, commercial laboratories, and scientific societies. There is obviously room in these classes for many different varieties of research work, and it is interesting to note that in some cases purely industrial concerns carry out a considerable amount of research in pure science, which they regard as a public service. The reader cannot fail to be impressed by the lavish scale on which many such institutions are carried on, and here Mr. Fleming has done a useful service by including in his account a series of photographs showing the exteriors and equipment of typical laboratories.

We believe that these illustrations will serve to convey to readers, much more vividly than any verbal description could do, the magnitude of these undertakings. The inclusion of such photographs in a Government publication is a welcome departure which, we hope, will be followed in many such scientific productions in the future.

Another step on which the Department are to be congratulated is the issue of an appropriate abstract of the Report, which should be very helpful to technical journalists and others who wish to obtain a rapid but exact survey of its essential points. We notice that, in emphasising the desirability of bringing constantly before the public mind the benefits to be derived from scientific and industrial research, Mr. Fleming alludes to the services that can be rendered by the Press, especially journals of a scientific, technical, or trade character. Such journals could play an important part in informing the public on these matters, and it is essential that they, in turn, should be kept fully informed of what the Department is doing. Co-operation with the scientific and technical press in such matters requires to be carefully fostered. Concise information as to what has been done in this direction abroad is most useful, and we hope that it will be followed by concrete examples of the advantages that have already been gained by the application of scientific knowledge by leading manufacturers in this country. The dissemination of such information in the scientific and technical press cannot fail to have a stimulating influence on industry and will be well repaid by the progress to which it gives rise.

Radium Luminous Compounds.

In the March issue of the ILLUMINATING ENGINEER we commented upon the interesting discussion of "Fluorescence and Phosphorescence, and their use to Produce Luminous Effects," initiated by Mr. F. Harrison Glew at the meeting of the Illuminating Engineering Society on March 22nd.

The series of investigations on Radium Luminous Compounds, described in a paper by Messrs. Paterson, Walsh and Higgins before the Physical Society on May 25th, form a useful supplement to the foregoing discussion, and we are giving an abstract of this paper in the present issue (pp. 137-141). The most interesting feature in the paper is a series of curves showing the progress of the decay in brightness of radium compounds of various strengths. The main conclusion reached by the authors seems to be that for compositions which are intended to be used for long periods there is little advantage in using a strength of radium exceeding 0·2 milligram per gramme of composition. This is a useful result in view of the expensive nature of these compounds, and also because they are so frequently kept in store for a considerable period previous to their being actually employed in practice.

The description of the photometric difficulties encountered, and the apparatus used in overcoming them, generally bears out what was said at the meeting of the Illuminating Engineering Society. No doubt when the war is over similar tests by other observers will be available, and it will be interesting to compare them with those now published.

One would also like to know what steps have been taken to ascertain the exact order of luminosity necessary for the various functions of these paints. On the ground of expense it is desirable to diminish the radium content as far as possible, and, in view of the high sensitiveness of the eye in total darkness, it is possible that a very minute proportion of radium, yielding a luminosity much less than that commonly employed, might sometimes be found to be sufficient. The determination of the best sizes of figure for luminous dials, described by the authors, is a good instance of how such problems should be investigated. In course of time the uses of radium luminous paint will probably be considerably extended, and the question of brightness in relation to conditions of use will doubtless be studied in fuller detail.

The authors do not enter into the complicated problem of the chemical and physical conditions which give rise to fluorescence and phosphorescence. An interesting letter, just received from Dr. J. E. Sheppard, of the Eastman Kodak Co., which we contemplate publishing in our next number, suggests that the chemical conditions giving rise to these two phenomena are essentially different. The study of such effects may yield much useful information as to what takes place within the atom, and may eventually profoundly influence present theories of chemical and physical action.

LEON GASTER.

TRANSACTIONS

OF

The Illuminating Engineering Society.

(Founded in London, 1909.)

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

ECONOMIES IN LIGHTING IN RELATION TO FUEL SAVING.

(Discussion at the Annual Meeting of the Society held at the house of the Royal Society of Arts, 18, John Street, Adelphi, London, W., on May 15th, 1917.)

At the conclusion of the formal business at the annual meeting of the Society, which was reported in our last issue,* a discussion took place on "Economies in Lighting in relation to Fuel Supply," the President-Elect, Mr. A. P. Trotter, being in the Chair.

The discussion was opened by an introductory address by Mr. L. Gaster.

Mr. L. Gaster said that the subject for discussion had a special interest for the Illuminating Engineering Society, which included amongst its members engineers concerned with the supply of gas and electricity, makers of lamps and lighting appliances (gas, oil, acetylene, electricity, &c.), and users of illumination on a large scale.

The first point to consider was the extent of the economy in fuel that could in any circumstances be expected to result from restriction in lighting. We should then consider this possible saving in relation to its effect on industry, public convenience, and safety. Artificial light was no longer regarded as a luxury, but as a public necessity, in the same way as fresh air, heat, and water supply. The Report of the Departmental Committee on Lighting in Factories and Workshops, issued in 1915, placed illumination on the same footing as these commodities—as an essential item in industrial work. We should, therefore, select carefully the directions in which economy is to be exercised.

According to the Estimates issued by the Board of Trade (issued March 17th, 1917), the output of coal in the United Kingdom during the last four years was as follows:—

	Million tons (approx.)
1913	287
1914	265
1915	253
1916	256

While, therefore, the output during 1916 showed a small advance over 1915, there was still a diminution of over 30 million tons as compared with the last year before the war.

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* *Illum. Eng.*, April, 1917, pp. 103-107.

In giving evidence before the Committee on the Summer Time Act, Mr Faraday Proctor, the Hon. Secretary of the Incorporated Municipal Electrical Association, stated that the total units generated for both electric light and power is about 2,000 millions, and of this about 23 per cent. is estimated to be used for lighting. Assuming, roughly, 4½ lbs. of coal per unit sold, this would be equivalent to about one million tons of coal used for the lighting load.

Similarly, Mr. Hanbury Thomas, of the Sheffield United Gas Co., estimated the total consumption of coal by the gas industry in 1915 to be about 18 million tons, of which probably about a quarter might be used for lighting. The consumption of coal for lighting by gas and electricity supply companies throughout this country was probably well within six million tons—only about 2½ per cent. of the total coal output.

Of this amount a very considerable proportion was required for indispensable purposes, *e.g.*, in munition and other factories, in necessary public lighting, &c. Therefore one must not form too extravagant a conception of the possible economies in the lighting field.

This impression was confirmed by a study of the saving estimated to be accomplished during the operation for 4½ months of summer time, by the Summer Time Act, in 1916. According to the Report of the Committee witnesses estimated the saving from reduction in gas lighting at about 260,000 tons, and the corresponding saving on the part of electric supply companies at less than 60,000 tons on the highest estimate. The combined saving thus amounted to only about one-tenth per cent. of the total coal output.

As regards the detailed effect of the Summer Time Act, the effect obviously varies greatly according to the locality and the proportions of output used for private lighting and for industrial purposes. Mr. Proctor estimated the saving as from 0·39—1·9 per cent. of the total units sold in the United Kingdom. In Manchester, however, the decrease in four residential districts was as much as 15 per cent., but in the industrial areas an increase was even recorded.

Yet, while the possible fuel-saving brought about might be small, in times like this any waste of light should certainly be avoided.

It appeared impracticable to aim at a general reduction of, say, 10 per cent, irrespective of the purpose for which the light is applied. It would clearly be folly to attempt undue diminution in munition works and factories where the expenditure in securing adequate illumination is small in comparison with the benefits secured in the form of improved output, avoidance of spoiled work, and better health and spirits of workers.

Similarly, any economy by additional indiscriminate reduction of lighting in the streets would surely be of small value in proportion to the risk to safety and the public inconvenience so caused.

As a preliminary to any restriction of lighting with a view to fuel economy the division of illumination into four main categories might be suggested :—

(1) Safety (as regards prevention of accidents).

(2) Lighting for indispensable purposes (munition works, factories, &c.).

(3) Lighting for public convenience.

(4) Luxury and spectacular lighting.

The first two divisions of lighting clearly ought not to be interfered with, except in cases where it could be clearly and indisputably shown that the light was excessive or wrongly applied for the purpose in view. Division (3) would only be touched in case of grave necessity, while Division (4) would be the first to which further restrictions should be applied.

The classification under these four headings would naturally require care. But there were instances of light being used in a way which, while permissible even if not really desirable in ordinary circumstances, was hardly justifiable now. The exhibition of large numbers of lamps, or very powerful lamps of undue brilliancy, outside shops and places of entertainment was a bad policy. By a little ingenuity it should surely be possible to attract the public attention without this species of glare, and in the present circumstances these incentives to visiting entertainments could not be considered strictly necessary.

In shop-window lighting, and in restaurants there is frequently waste of light. The allocation of a certain amount of gas or electricity to a shop-window for specified purposes or of given area might be considered, and methods of using the available light to the best advantage made more familiar to the general public.

In the first instance, it would probably be best to operate by educational methods rather than hard and fast regulations. If such an educational movement was based on the inculcation of the general principles governing the proper use of light (avoidance of glare, proper shading, &c.), it would have valuable results for the future, quite apart from its present utility as stimulating economy. One difficulty that would now have to be considered is the limitation in supply of efficient reflectors and other devices. But such appliances, though necessary to the highest development of lighting, are not absolutely essential in order to carry out the fundamental principles of good lighting, and many simple means of screening could be suggested that could be prepared without much trouble.

In conclusion, Mr. Gaster suggested that the whole question of economies in lighting should be referred to a Joint Committee, on which the Illuminating Engineering Society would be represented, during the summer months, with a view to advising the authorities regarding the best steps to be taken when the winter months arrived. Such a Committee, acting with official recognition and support, might survey the whole field of lighting, making broad classifications into the four categories suggested above, with due regard to the variety of circumstances in different districts. The same considerations as govern the division of industries into "essential" and "non-essential" would be borne in mind. Having further taken into account the effect both on the public and the lighting industry of any change, and the saving in coal that might be expected to result, it would be in a position to inform the Government where such a saving could be made with a minimum of risk and inconvenience.

Information of this kind would be of great value as a basis of action in the form of orders or legislation. The Committee might also prepare the ground for restrictions by drafting pamphlets for public distribution showing, by concrete examples, the amount of light necessary for various purposes, and the directions in which various sections of the public would be expected to economise.

Even should extreme economy in lighting happily be found unnecessary the information gained through such an inquiry would not be wasted but would provide useful material, especially to gas and electric supply companies, for the future.

The Chairman then called upon the Hon. Asst.-Secretary to read the following communication from Mr. H. Faraday Proctor.

Mr. H. FARADAY PROCTOR (*communicated*):— I believe it is a reasonable assumption that diminution in consumption of electricity due to economies being advocated would not exceed about 10%. Such a reduction would result in lowering the coal consumption of electrical undertakings by about 1½% only, having regard to the fact that the lighting units sold by electrical undertakers are only about 23% of the total units output. Such reduction would amount to about 60,000 tons of coal per annum for the whole kingdom.

The loss in revenue to the electrical undertakings would be in the neighbourhood of £500,000 per annum. As few, if any, electrical undertakers are making more than a reasonable profit on their capital outlay, a diminution in revenue unaccompanied by a corresponding diminution in costs must ultimately result in an increase in the charges, or at least in the postponement of a reduction of the same. In either case the consumer is not likely in the long run to reap a financial benefit commensurate with the reduction of his consumption of energy. It is, therefore, little use looking for a substantial reduction in coal consumption as resulting from economy in lighting.

To conserve coal the raw material must be used efficiently. The burning of coal as fuel prior to the abstraction of what we term, by-products, is in itself wasteful, but the great power stations are amongst the least sinful in their methods.

Assuming for the sake of argument that the coal consumption of the average, privately owned engine per H.P.-hour is double that of the engines in an up-to-date power house, the change over of only 16,000 K.W of load of 25% load factor from privately owned plant to public supply mains would result in a saving of about 60,000 tons of coal per annum. (The losses in beltings and other inefficiencies superseded being set against the electric transmission losses.) Thus a comparatively small change over by power users on to up-to-date methods of driving would result in economies that would balance those obtainable from general lighting economies, and would benefit all parties concerned.

Economy in lighting must be looked upon purely as a War measure, and that solely with a view to a small reduction in the coal consumption throughout the country. It must be realised that to bring about a substantial reduction in coal consumption wasteful methods must be abolished.

I trust and believe that in the near future the Government will bring pressure to bear upon the users of private plant, whether by taxation or otherwise, and they will be compelled to utilise the public supply wherever such is available on reasonable terms.

The end to be aimed at is that the burning of raw coal should be prohibited except to licensed users. The result would be enormous economies, and such a clear atmosphere in our country that, amongst other things, economy in artificial lighting would be the indirect result.

Dr. J. F. CROWLEY thought the suggestion that the matter should be considered by the Joint Committee a very sound one, because upon that Committee would be representatives who would be able to see to the interests of illuminating engineering, and would have in mind the struggle the Society had had since its formation to secure due attention to the principles on which sound lighting should be based.

Apparently the point the Government had in mind in suggesting economies in lighting was the saving in coal that it was anticipated would result. In this connection, he might mention that the output of coal per mine-worker per annum had been steadily falling in this country for the past fifty years, until it stood to-day lower than the output per mine-worker per annum of any country of comparable size in the world. Whatever the cause, and he was not going to enter into that, this meant that the conservation of coal would become an increasingly acute problem. Since the quantity of coal used for power purposes in this country was so very much greater than the quantity of coal used for lighting, it might be well to note that in all efforts that were being made to promote economy in the use of the coal used for power purposes there was no proposal to reduce the amount of power used in industry. On the contrary, the view was held that if we were to be successful in industry in thef uture, we must use power to a greater extent than hitherto. The conservation of our coal supplies, therefore, in so far as it applied to the coal used for power purposes could only be made effective by economy in the methods adopted for producing and applying power. In regard to lighting he felt also that our natural tendency ought to be to increase the quantity of light at present in use in industry rather than to restrict it, while securing the necessary economy in the fuel used for lighting purposes by the adoption of more efficient methods of illumination. He was assuming, of course, that the proposed economy in illumination was not a temporary war measure, which would necessarily have to be dealt with as such, but that it was being considered as part of the whole problem of the conservation of coal after the war now under review, and his suggestion was that every endeavour should be made to secure the most efficient methods of illumination in accordance with the principles the Illuminating Engineering Society had been inculcating for so many years, with restrictions only on luxury in lighting, display advertisements, &c.

As Mr. Faraday Proctor pointed out, the saving in the coal used for lighting purposes would in any case be a small matter, and our real saving would result from greater efficiency in the methods of producing and distributing power, to which he had already referred.

Mr. J. S. Dow said that although it was generally agreed that the saving possible in the amount of coal used for lighting purposes was a small fraction of the whole, yet it must be remembered that the margin available for lighting in normal times was also small. The reduction of output since 1913 was greater than the amount normally allotted to lighting. Therefore in this field even a small saving might be important. In some districts at the present time supply companies found a difficulty in coping with the industrial demand, especially during the peak hours. If purely luxury and spectacular lighting could be diminished in these hours it might be of material help, and it was surely better to make sacrifices in this direction than to run the risk of insufficient industrial supply.

Moreover, the elimination of waste of light formed part of the Society's permanent programme and it was natural and legitimate to extend their educational work in this direction at the present time when waste was specially undesirable.

Mr. Gaster had referred to the display of bright lamps outside places of entertainment; if persisted in during the winter days this was a not inconsiderable item, and in the present darkened condition of the streets glaring methods were particularly objectionable. The matter was also of importance for the future because, when the lighting restrictions were removed there would be a danger of a reaction towards the indiscriminate display of bright lights—especially in view of the ease with which the half-watt lamps could be installed. It would be much better if more artistic and economical methods, such as the flood-lighting now becoming usual in the United States, could be brought to the notice of such consumers.

In regard to shop lighting, again education in the proper use of light was badly needed. Many crude and wasteful methods such as the use of naked lamps or lamps screened with coloured paper still survived. The Society had for years advocated the screening of sources so as to throw the light on the goods, the lights themselves being invisible from outside the window.

These would be matters for the consideration of the Committee Mr. Gaster had suggested, and it might be a good plan for the members to prepare readable pamphlets, addressed to various sections of the community, pointing out the essential principles of good lighting and the inconvenience of wasteful display.

The CHAIRMAN (Mr. A. P. Trotter) said he had given some attention to the matter but had found the problem somewhat complicated. A distinction should be drawn between general economy and war economy. Circulars had already been issued asking the public to economise in lighting for the sake of the ensuing saving of coal. But when we came to consider the economy of a spontaneous nature which most people were now practising in their domestic arrangements it would be found that the coal saved was small in comparison with the saving in lighting bills—certainly not more than 10 per cent., or one penny in the shilling, in the personal saving to the pocket of the consumer.

At the same time he thought there were directions where economy might fitly be exercised. They all remembered what a dismal place London had become before last Christmas. The modification in the general lighting had been welcome, but there was a great deal of unnecessary lighting outside theatres and restaurants. As Mr. Gaster said, people knew where to go for entertainment without it being necessary to attract them by a blaze of light. The lighting outside some tobacconists' shops in the Strand was absolutely painful and dazzling. Such conditions were always undesirable and particularly so at present; yet, while economies in this direction might be expected now, he was not sure that it would not be considered undue interference with the liberty of the subject to say that this must not be done after the war.

There was one considerable waste going on in many parts of London, namely the lighting by arc lamps in opal globes, the surfaces of which were painted black, or nearly so. This was absurdly extravagant. Such lamps originally took 9 amperes and even now were taking 7 amperes, and the current could not be further diminished without interfering with the regulation of the lamp. These lamps could be replaced by small incandescent lamps giving more light but taking far less current. With a 60-volt lamp no alteration in the wiring would be required and why such an obvious economy was not more widely practised he could not imagine.

Mr. L. GASTER, replying to various points in the discussion, said that the question of economy in the use of coal for power production, referred to by Mr. Faraday Proctor and Dr. Crowley, was a most important matter. The various speakers agreed with him that the saving in coal through lighting diminution was necessarily a small item. Nevertheless, the consideration of lighting had a moral justification because this form of waste came so prominently before the public eye. The general public, who probably did not understand that illumination was responsible for but a small fraction of the total coal consumption, were apt to assume, when they saw evidence of the lavish display in lighting, that the need for economy was not so great as had been represented.

In addition, as Mr. Dow had remarked, our present action must take account of the future. If people could be induced to adopt proper methods of lighting now they would be less likely to return to wasteful ways when the present restrictions were removed.

In view of the fact that the authorities were already considering this matter, he thought that the formation of a small Joint Committee by the Society would be helpful. It would be able to assist them by pointing out directions in which lighting economies could be exercised without undue hardship and in preventing hastily contrived regulations which tended to undermine authority and create dissatisfaction.

It was naturally impossible for Government Departments, in these times of pressure, to survey the entire field and take account of circumstances which were only familiar to technical men. As a matter of principle Government Departments should welcome the assistance of scientific and technical societies in surveying the ground and providing statistical data before regulations were made.

A cordial vote of thanks to Mr. Gaster terminated the discussion, the Chairman remarking that the formation of the suggested committee might be safely left in his hands.

It was announced that the opening meeting of the next session would take place in November.

SIGHT AND SIGNALLING IN THE NAVY.

A contribution by A. Duane in the Proceedings of the American Philosophical Society (No. 5, Vol. LV., 1916) describes in detail the various types of signals—semaphore, flashing lights, fixed and moving colours, special forms, etc.—that a skilled signalman in the Navy must interpret. Expertness in this branch makes a severe call on the efficiency of the eye. It is recommended that "the standards of vision and colour vision now required in the Navy should by no means be diminished but rigorously maintained." Tests should relate not only to vision (perception of form and colour) but also to the reaction time required to receive and record impressions.

Obituary.

We learn with regret of the death in action of Corporal L. S. Anderson, Manchester Regiment, who was reported missing in July last, and now officially presumed to have been killed on that date.

Corporal Anderson was a member of the Illuminating Engineering Society, and, previous to joining the Forces, was associated with the Lancashire Electric Power Company.

AN INVESTIGATION ON RADIUM LUMINOUS COMPOUND.

By CLIFFORD C. PATERSON, J. W. T. WALSH and W. F. HIGGINS.

(Abstract of a Paper read before the Physical Society on May 25th, 1917.)

IN this Paper is given an account of work carried out at the National Physical Laboratory on Radium Luminous Compounds. The investigations originated in a request by the Admiralty for information and assistance in connection with the use of this material for the dials of large numbers of instruments used by the Navy.

The standard of luminosity for the paint (generally known as the N.P.L. Standard) was fixed in absolute measure in December, 1915, and that foı the dials themselves shortly afterwards, and many thousands of luminous instrument dials have since been passed through and measured for conformity with the standards laid down.

The subject is a comparatively new one, for the value of radium luminous compound has only been recently recognised in connection with commercial apparatus. Photometric measurements of the brilliancy of zinc sulphide under the action of the radiations from radium products were made by Marsden in 1910,* who directed the radiation from a tube of emanation on to a zinc sulphide screen and measured the luminosity produced. The luminosity was found always to decay at a more rapid rate than the emanation.

In a Paper in 1915,† Mr. H. Hughes, describing the Creagh-Osborne compass, dealt with the use and appplication of radium compound to prismatic compasses, and in a further Paper to the Optical Society in June, 1916, F. Harrison Glew‡ dealt with the general question of luminescence, and considered the practical uses to which radium luminous compound may be put, as well as the method of application of the compound to a surface in order to produce the maximum luminosity. Mr. Glew gave a further lecture on this subject to the Illuminating Engineering Society,* followed by notes on the behaviour and testing of luminous paint by Mr. J. S. Dow and Mr. A. Blok.

Measurement of Luminosity.—The measurement of the luminosity of radium paint is rendered difficult by two considerations—(i.) the green hue of the light emitted, (ii.) the very low brightness to be measured. It is desirable at the outset to make determinations of luminosity in absolute rather than relative measure, and comparisons have therefore to be made with the ordinary photometric standards.

(i.) The very green hue of the light given by radium compound necessitates the use of a green filter when photometering it. A good match is obtained by the use of a sample of glass made by Messrs. Chance Bros., known as "B.O.T. Light Green," and corresponding with the lightest shade of green glass permitted for ships' staıboard navigation lights. The expression of the luminosity on absolute measure entails the determination of the transmission coefficient of the filter.

(ii.) The degree of brightness required to be measured is of the order of 10 microcandles per square centimetre, or 0·03 equivalent foot-candle.†

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* Roy. Soc. *Proc.*, lxxxiii., pp. 548-561, 1910 *Sci. Abst.*, lxxvi. A., 1911.

† *Improvements in Prismatic Compasses*, H. A. Hughes, *Trans.*, Opt. Soc., Lond., Vol. xvi., p. 17.

‡ *Radium and Other Luminous Compounds*, F. Harrison Glew, *Trans.*, Opt. Soc. Lond., Vol. xvi., p. 276.

* *Illum. Engineer*, March, 1917.

† This is a convenient unit of brightness, and represents a brightness equal to that of a perfectly diffusing surface with a coefficient of reflection of 100 per cent., when illuminated to an intensity of 1 ft.-candle (*i.e.*, by a source of 1 candle placed 1 ft. away from the surface in the direction of its normal).

This degree of illumination is one at which the Purkinje effect is operative, so that the transmission coefficient of the green filter must be determined at an illumination corresponding with the brightness of the paint with which it is to be used, and it must be ensured that the surfaces to be compared are really in juxtaposition without any intervening space to separate their images on the retina.

The apparatus is shown diagrammatically in Fig. 1.*

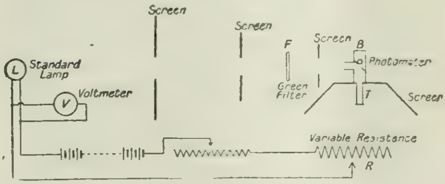

FIG. 1.—Diagram of Apparatus for measuring the Brightness of Radium Luminous Compound.

L is a tungsten filament lamp mounted on the carriage of a 30 ft. long photometer bench. It is fed from a storage battery, the pressure at the lamp terminals being controlled by a resistance, R, which is to the hand of the observer. The value of the pressure applied to the lamp terminals is indicated by a voltmeter, V. F is the special green filter. It reduces the hue of the light given by L to that of the radium compound. B is a small brass box, 120 mm. long by 37 mm. square, and shown in more detailed plan in Fig. 2.

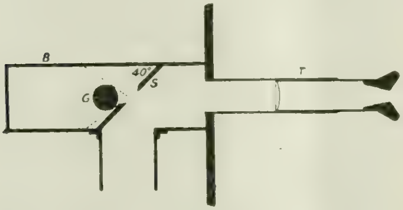

FIG. 2.—Detail of Box containing the comparison surface and tube of compound.

It contains S, a sheet of matt white celluloid set at an angle of 50 deg. to the axis, in the centre of which is cut an oblong aperture, 4·5 mm. high by 7mm. broad. The relative dimensions are such that when the screen is looked at through the telescope the aperture has the appearance of a small square with 4·5 mm. sides. This aperture is cut with a sharp bevel, so as to reduce to the smallest possible dimension the black edge between the illuminated screen and the surface of the radium compound.

The radium compound is contained in a glass tube, G, and wedge-shaped guides are arranged inside the box to assist in placing it centrally behind the aperture in S, no matter what may be the diameter of the tube.

The transmission coefficient of the filter F was determined from the mean results of five experienced photometric observers, each of whom matched the brightness of three separate samples of radium paint against the brightness of the screen S. The illumination of S was varied by moving the lamp L along the line LF until a match of intensity was obtained. This was done (i.) with the filter F removed and, (ii.) with the filter in place. The mean ratio of the illuminations was taken to represent, for the conditions under which the apparatus is used, the transmission coefficient of the filter for an "average" eye.

Absorption of Glass Tubes.—The radium paint being in powder form, it is necessary to measure its brightness when enclosed in a glass tube.

Variations in the thicknesses of the glass containing tubes, up to at least 1·3 mm. makes no difference to the brightness of the paint viewed through them.

The coloration of the glass by the action of the radium, on the other hand, produces a progressively increasing absorption for which allowance has to be made in considering the decay of luminosity of the compound. Lead glass gives a brown coloration and soda glass a purple one.

Measurements have been made of the amount of this effect in the case of six of the samples of compound studied, all of which were contained in soda glass tubes. The results are given in Table I.

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* A very similar apparatus is described by Mr. Blok to the Illuminating Engineering Society, March, 1917.

TABLE I.

Sample.	Age of compound.	Total absorption due to coloration.
	Months.	Per cent.
3	14½	13
6	17	8
7	17	9
8	11½	10
9	13	10
10	13	16

Testing of Dials.—The only satisfactory way of testing the actual brightness of the luminous markings, is to compare the dial under test with another dial the markings of which are of the same pattern and dimensions, and of known brightness.

This was done with the apparatus shown in Fig. 3 which consists of a box which encloses at one end an electric lamp, L, in circuit with a resistance, R, and precision ammeter A. R is to the hand of the observer. L is actually a 105-volt 60-watt metallic filament lamp operated when giving standard brilliancy at about 5 watts per candle. In front of L is a sheet of Wratten "Minus Red" filter F, in order that the hue of the light may match that of the radium compound. The green light then falls on two screens SS, each consisting of two thicknesses of thin white paper with a space of 10 mm. between them. In front of the screens are placed two stencils TT, each consisting of a sheet of thin brass or copper 0·3 mm. thick, framed in wood to fit the dimensions of the screens (255×275 mm.). The figures and graduations are cut in brass on an engraving machine, so as to be identical with the luminous markings of the dials under examination. Between the stencils is fixed the dial under test D.*

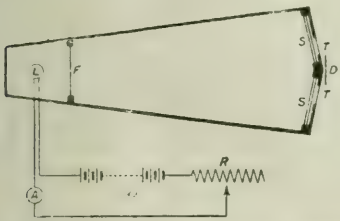

FIG. 3.—Diagram of Apparatus for Measuring the Brightness of the Markings of Luminous Dials.

The test is made by adjusting the current furnished to the comparison dials until the three dials are of equal luminosity the current then furnishing an indication of the absolute brightness. The luminosity on standard dials is 0·0075 equivalent foot-candle.

As a result of investigation it has been found the proportion of width of line to height of letter for maximum legibility should be about 1 to 8, and should not much exceed 1 to 7, at any rate for letters and figures in which the height exceeds about 5 mm. Below this limit experience suggests that the breadth of line may be usefully increased to one-sixth of the height of the figure.

Decay of Luminosity.—It is known that the luminosity of radium paints, both in the form of powder and varnish, first rises to a maximum after mixing, and then commences to fall, at first gradually, then more rapidly, until after six or seven weeks from the date of mixing the rate of decay settles down into a logarithmic law ($B/B_0=e^{-k}$). This law applies for a period of 150—200 days, but after that period the luminosity diminishes less rapidly than the law would suggest.

Some typical results are shown in Fig. 4.

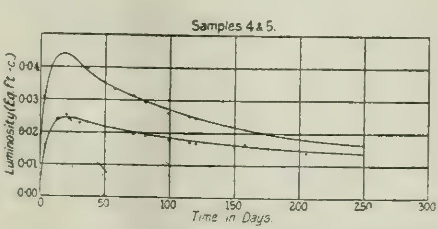

FIG. 4.—The Early Portions of the Luminosity Curves for Samples of Compound containing Radium in the proportion of 2 : 1.

Fig. 5 shows a family of luminosity curves based on the average data at present obtained for compounds made up with different proportions of radium.

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* The advantages of this position of the dials were discussed at the meeting of the Illuminating Engineering Society on March 22nd. See *Illum. Eng.*, March, 1917, p. 87.

salt in the same quality of zinc sulphide, this sulphide being assumed to have characteristic constants of a fair average value.

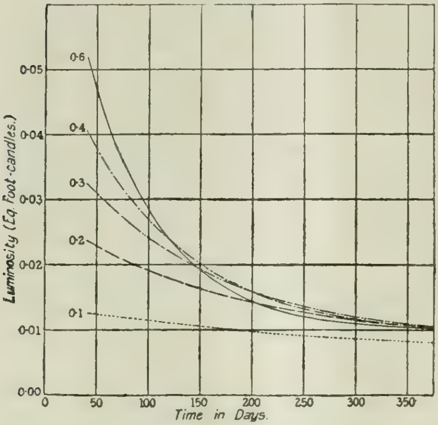

FIG. 5.—Theoretical Luminosity Curves for Samples of Radium Content (mg./gm.) shown against each Curve. (Constants of Decay assumed of Fair Average Values.)

It is interesting to note that the luminosity standards for the dry compound and for the painted dials are 0·03 and 0·0075 ft.-candles respectively, *i.e.*, in the ratio of 4 : 1. If we assume curve 0·4 of Fig. 5 to represent the behaviour of the compound before application to dials the 0·1 curve may be taken to represent, both as regards initial brightness and decay, the behaviour of the material after painting.

For the compound alone (as distinct from painted dials) after the first six months, the luminosities of compounds of all contents between 0·2 mg. per gramme and 0·8 mg. per gramme are the same to within 20 per cent.

In the case of instruments of which the life under normal working conditions is appreciably less than six months the use of a compound containing, say, 0·6 mg. per gramme or over might be of advantage provided it could be ensured (*a*) that the dials were painted within three weeks of the preparation of the compound, and (*b*) that the instruments were not kept in store for more than a month after painting. Probably, in ordinary circumstances, these conditions would not be easy of realisation, and the use, therefore, of a compound of greater radium content than about 0·4 mg. per gramme may be ruled out.

In cases in which the compound is employed in powder form, the minimum useful radium content is only a little below 0·2 mg. per gramme, and except on the score of expense alone it is not desirable to employ a compound of less radium content than this, because the luminosity of the 0·1 mg. compound after an indefinitely long period is still nearly 20 per cent. below that of the 0·2 compound.

Similarly for compound used in painting dials, 0·4 mg. per gramme is the best content to use if final luminosity is not to be sacrificed. Some 50 per cent. saving of cost should result from the use of compound for painting dials containing 0·2 mg. per gramme, but the final luminosity would be somewhat less. It should be remembered that there is nothing appreciable to be gained by the use of compounds for dials *below* this last-named limit because it will be nearly as economical, and a better result will be achieved by employing a smaller quantity of the better grades of compound instead of the large quantity of a compound of lower radium content.

DISCUSSION.

Mr. F. H. GLEW pointed out the difference in brightness occurring if tubes are painted on the inside and the radioactive effect had to pass through the material in order to produce luminosity. He also suggested that it might be preferable to place the colour-filter in the eye-piece of the photometer instead of between the lamp and the screen.

Dr. H. S. ALLEN said that an investigation of the physical condition of the zinc sulphide used would be useful.

Mr. J. S. DOW referred to the difficulty of specifying a standard of absolute brightness, and the change in the colour of the light, which apparently became greener as the decay progressed. He had carried out a test on a tube painted inside with zinc sulphide and containing radium emanation. The original brightness of this was as much as 1/5th of a foot-candle, but in three weeks it fell to 1/60th of this value. A marked effect in this tube was the formation of local bright spots, to which Mr. Glew had drawn attention.

Dr. LEVY said that different samples of zinc sulphide yielded light of distinctly different hues when stimulated by daylight, but he had not noticed any difference when they were stimulated by radium. A specimen might be poor with daylight but good with radium excitation, but the converse did not hold good.

Mr. T. SMITH advocated placing the coloured screen as near the lamp as possible, as this itself might appreciably act as a source of light. It would be better to enclose the material in a tube with flat sides rather than a round tube.

Dr. S. RUSS asked if tests of the decay of fluorescent screens for use with X-rays had been made.

Mr. WALSH, in reply, pointed out that the use of a colour-filter in the manner suggested by Mr. Glew would involve a double correction. Changes in colour with age and in different samples submitted had been observed, but were not easy to measure quantitatively. They had no data on the relation between daylight and radium excitation. The order of accuracy was not appreciably affected by the position of the coloured screen. As regards the enclosing tubes, they had to employ those in which the material was sent.

ARC LIGHT UNDER PRESSURE.

Some experiments on the operation of electric arcs under pressure are described by Dr. W. Mathiesen in the *Electrotechnische A. Zeitschrift.** An increase in efficiency might be obtained in this way, but there appear to be difficulties in the employment of such pressures at present. Pressures from 3·4. atmospheres vacuum up to 5 atmospheres compression were studied. With an inclined negative carbon an increase in pressure from 0 to 5 atmospheres raised the efficiency from 0·26 to 0·13 watt per candle, but in general at the higher pressures the arc becomes very unstable. While it is possible to work up to 5 atmospheres with vertical carbons, in the case of inclined carbons the arc becomes too erratic if 1 atmosphere is exceeded. A test reported for vertical carbons suggests that the gain in efficiency with vertical carbons is not great, the specific consumption with a rise in pressure from 0 to 3 atmospheres falling from 0·725 to 0·68 watts per candle, and then subsequently increasing at 5 atmospheres to 0·945 watts per candle.

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* Oct. 12th and 19th, 1916.

THE NERNST VAPOUR LAMP.

Some recent patents of Dr. Nernst* relate to arcs struck between carbon electrodes in atmospheres of zinc, aluminium and titanium chloride. The latter appears to be specially suitable for the object in view. The efficiency obtained in such lamps is said to be similar to that obtained with mercury vapour lamps. A resistance in series with the arc is utilised to volatilise the salt used.

In a second patent suitable salts are added to mercury vapour to produce a white light. Special arrangements have to be made to prevent the foreign ingredient being gradually removed by the mercury. A suitable mixture proposed is 70 per cent. zinc chloride, 15 per cent. calcium chloride, 5 per cent. thallium chloride and 5 per cent. caesium chloride. Such a lamp, taking 4 ampéres at 120 volts, is stated to give 3,000 Hefners and operate at 0·16 watt per Hefner.

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* *Elektrotechnische Zeitschrift*, Vol. 40, 1916; abstr. *Electrician*, June 8th, 1917; German patents 288,228 and 288,229.

FLOOD-LIGHTING OF THE CAPITOL, WASHINGTON.

REFERENCE has been made in the *Illuminating Engineer* to the interesting precedent established by the use of flood-lighting to illuminate the Capitol in Washington, U.S.A. This is a building of architectural distinction as well as national interest, and possesses an imposing dome which has been likened to that of St. Peter's in Rome.

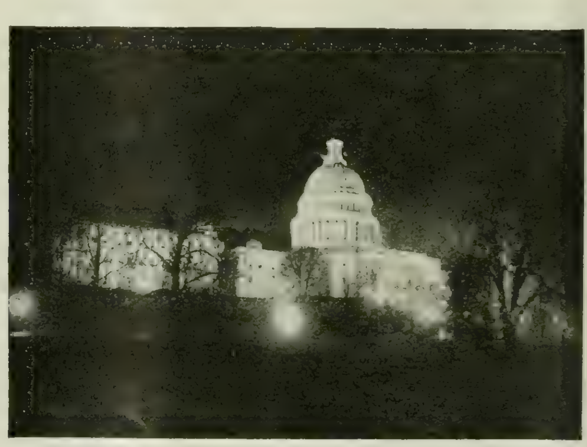

FIG. 1.—General View of the National Capitol (Washington) under Flood-Lighting.

The external lighting of this building was specially designed to show up its proportions and characteristic architectural features. An interesting account of the arrangement was contributed by Mr. J. A. Summers to the *General Electric Review* (U.S.A.) for May, from which these particulars and the accompanying illustrations are reproduced.

The Capitol stands on a hill overlooking the Potomac river and can be seen for many miles around. It is even more striking when illuminated by night. The dome is 135 feet in diameter at the base and 218 ft. high above the roof. Around the base are fluted columns.

The lighting installations consisted of 84 flood-lighting projectors each equipped with a 400-watt incandescent lamp. The projectors were placed in four banks, 21 in each bank, about 200 feet from the base of the dome on the corners of the House and Senate wings of the building. The positions of the units were carefully selected with a view to cutting out unduly sharp shadows, the columns being illuminated from different directions so as to avoid any harsh effect and yet prevent an impression of "flatness."

The building itself was illuminated to a lower intensity, so as to form a setting for the dome. In ordinary circumstances the building receives a certain amount of illumination from a few ornamental posts with lamps in white opal globes, placed at regular intervals on the parapet. To provide additional illumination thirty-four supplementary posts in the same style were added, but each carried a 400-watt floodlighting projector instead of the customary opal globe. It is stated that the units were not at all conspicuous.

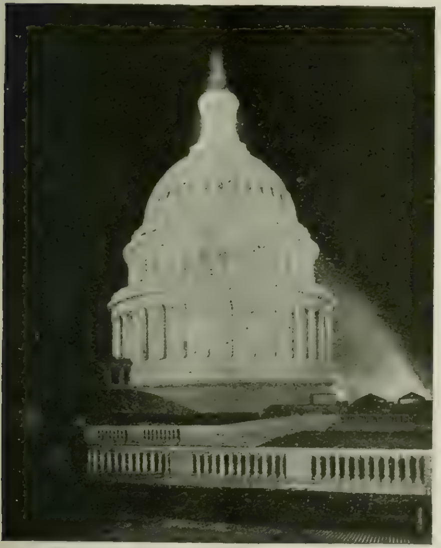
Fig. 2.—Dome of Capitol (Washington), illuminated by Flood-Lighting Projectors.

The effect of the lighting may be judged from the accompanying illustrations. The illumination was first used on the occasion of the inauguration of the building by President Wilson.

FLOOD-LIGHTING STAINED-GLASS WINDOW.

An interesting application of flood-lighting is reported from the United States in a museum devoted to art work of various kinds. There was on exhibition a very fine stained-glass window, which on bright days could be readily shown, but on dull days could not be exhibited satisfactorily, as the colours were not well brought out by the relatively weak light.

This difficulty has been overcome by fixing, some distance outside the window, a gas-filled lamp in a concentrating reflector so as to illuminate the window by artificial light. The effect is said to be quite good, and the window can now be exhibited independent of the climatic conditions. The relatively white light given by the gas-filled lamp is also considered to be an advantage.

A NEW STYLE OF STREET LIGHTING.

We notice that in Brownwood, Texas, a town of about 12,000 inhabitants, a somewhat novel system of electric lighting is being installed. The method consists in placing a 100-watt lamp in opal globe under the awning of each shop entrance. It was agreed that the system would not be applied to any block unless the entire block was uniformly lighted. About 400 lamps have already been installed, and it is stated that a good effect on the window lighting has also been produced, quite a number of prominent stores taking the opportunity to bring their illumination up to date.

REVIEWS OF BOOKS.

Hawkins' Electrical Guides. (Messrs. Edwin A. Mansfield and Co., Electrical Engineers, 12, *Beckenham Road, New Brighton.* 5*s. per vol.*; £2 10*s. the complete series of* 10 *volumes.)*

We have had an opportunity of inspecting the *Hawkins' Electrical Guides,* a series of volumes emanating from the United States.

The subject-matter covered by the series is as follows :—

No. 1. Elementary Electricity, Magnetism, Induction, Dynamos, Electric Machinery.

No. 2. Construction of Dynamoes, Motors, Armatures and Armature Windings, Installation of Dynamos.

No. 3. Electrical Instruments, Testing, Practical Management of Dynamos and Motors.

No. 4. Distribution Systems, Wiring, Wiring Diagrams, Sign Flashers, Storage Batteries.

No. 5. Alternating Current and Alternators.

No. 6. Alternating Current Motors, Transformers, Converters, Rectifiers.

No. 7. Alternating Current Systems, Current Breakers, Measuring Instruments.

No. 8. Alternating Current Switchboards, Wiring, Power Stations, Installations and Operation.

No. 9. Telephones, Telegraph, Wireless, Bells, Lighting, Railways.

No. 10. Modern Practical Applications of Electricit,y and Index.

To cover such a variety of ground is certainly a *tour de force.* The language is concise and simple, and the guides are stated to "give a complete course in electrical engineering without correspondence." Those who, as instructors in technical colleges, have grappled with the task of explaining the fundamental principles of alternating currents and dynamo-electric machinery, will appreciate the difficulty of grasping such conceptions through the printed page. In this case the difficulty is partly met by a lavish use of illustrations and the insertion of queries and answers on the subject-matter.

While in our opinion nothing can adequately replace personal contact between professor and student, and the handling of concrete things in the workshop and laboratory, the possessor of these guides has a series of reference books containing a considerable amount of information. They would form a useful supplement to courses of instruction or workshop experience.

Electrical Engineering Practice, by J. W. Meares and R. E. Neale. (E. and F. N. Spon and Co., Ltd., 57, *Haymarket, London.* 521 *pp.,* 86 *illustrations. 3rd Edition.* 25*s. net.)*

This work, in its present extended form, makes an attempt to fill the gap between pocket-books of bare data and highly technical treatises. The language is concise, and the authors have illustrated each point by many practical illustrations and useful data.

The early chapters are elementary, but the reader is soon led on to practical information of wiring, lamps, motors, and installation work generally. Power transmission, traction, hydro-electric plant, and electric driving receive special attention, and there are two final chapters on specifications and testing. We notice that illumination is dealt with, necessarily briefly, but in an up-to-date manner.

The authors appear to have been careful in their choice of symbols, and the list of books for reference at the beginning of the book is a useful feature. Possibly, in view of the wide ground covered, it might be useful in a future edition to add to certain chapters a list of some of the chief contributions to proceedings of technical societies or technical journals indicating where more detailed information may be found.

SHORT NOTES ON ILLUMINATING ENGINEERING.

INVESTIGATIONS ON INCANDESCENT MANTLES.

We understand that the Bureau of Standards (Washington, U.S.A.) has been conducting an exhaustive investigation on the efficiency of incandescent gas mantles, with special reference to the influence of varying quality of gas.

Inspections of more than 6,000 installations in ten different cities have been made, and it is believed that the results will strongly illustrate the benefits of regular attention in the maintenance of lamps and fittings.

It is stated that a report on the whole subject is in course of preparation.

THE OPTICAL SOCIETY OF AMERICA.

In the Transactions of the Illuminating Engineering Society, U.S.A., it is mentioned that an Optical Society has recently been formed in America for the study of optics and optical instruments and apparatus.

The officers of this new Society include a number of active members of the Illuminating Engineering Society, the President for the current year being Mr. P. G. Nutting.

SPECIAL LIGHTING FITTINGS.

At a meeting of the South-Western Electrical and Gas Association, held in Dallas, Texas, U.S.A., on April 26th, Mr. J. G. Barret read a paper on "Illumination *versus* Raw Light." The author pointed out the value to supply companies of encouraging the design and use of special lighting fittings for specific purposes, which would often result in new lighting business being opened up. Among the units of this kind he mentioned porch lights, lights for school buildings, "daylight" illumination for shops, ribbon counters, &c.

The object of the company should be to demonstrate the convenience and ease of application of electric light for all purposes, and therefore the use of special appliances for specific purposes should be generally encouraged.

STREET LIGHTING WITH OIL LAMPS IN PARIS.

Centuries ago Paris was the foremost city in Europe in the provision of oil lanterns in its streets. In a contribution to the *American Gas Engineering Journal* Mr. F. Miltoun states that hundreds of these old lanterns still exist, and some of them are now to be seen burning feebly at the street corners. It is proposed that the famous Esplanade des Invalides will be so lighted.

This step appears to be a precaution in view of possible shortage of gas. Since the outbreak of war the situation in this respect has become more acute, and though gas is still sold at 20 centimes, it is said to cost 28 centimes to produce. According to Mr. Miltoun, no new installations are being made at the present time.

ECONOMIES IN PUBLIC LIGHTING.

In the House of Commons Mr. Lough recently asked the Home Secretary whether any Borough Councils had intimated their desire to economise coal and other supplies by reducing public lighting during the summer; whether certain gas companies had stated that they were unable to carry out the reduction because of the Lighting Regulations under the Defence of the Realm Act; if so whether the Government still regarded economy in coal consumption as desirable? Further, would he take steps to make it clear that local authorities should be enabled and encouraged to bring about economies by reducing waste of gas and electricity in the same way as had been accomplished by the regulation prescribing the early closing of shops?

Mr. Brace replied that representations on the subject had been received from several Borough Councils. It was most desirable to secure economy in consumption of coal in every possible way, but important for military reasons that any reduction in lighting should be carried out uniformly throughout the Metropolitan area. He had been in communication with the military authorities on the matter, and hoped in a few days to communicate with the Borough Councils with a view to securing such saving as might be possible during the summer months.

SUMMER TIME IN GERMANY.

According to the *Gas World*, the German Gas Association some time ago circulated its members with a view to eliciting opinions regarding the effect of the "summer time" also being adopted in that country.

The general impression appears to be that the saving brought about has been small. Gas companies have not been very favourably affected, as although it has presumably led to a small coal saving, the fixed charges remain.

It is interesting to observe that according to the statistics obtained by the Gas Promotion Centre the effect of summer time was to cause a drop of about 5 per cent. during the summer months, which is approximately 1·7 per cent. of the annual consumption.

This is curiously close to the estimate made by Mr. Faraday Proctor, in his evidence before the Committee on the Summer Time Act, of the saving in electricity brought about in this country.

OPTICAL TECHNOLOGY IN FRANCE.

It is interesting to observe that, according to *La Nature*, proposals are now being made in France to secure greater facilities for training in optical technology. The proposals include a College of Optics, a Central Laboratory for Optical Testing and Experiments and a special Optical Trade School. It is also suggested that a suitable journal, devoted exclusively to optics and optical instruments, should be published.

It is pointed out that this subject is of interest to a wide circle of the public, including officers in the Army and Navy, illuminating engineers, manufacturers of optical instruments and appliances and many others.

THE SOCIETY OF GLASS TECHNOLOGY.

A meeting of this newly-formed Society was held at the Institute of Chemistry, by invitation, during May, Mr. A. S. Esslemont presiding. Professor Herbert

Jackson, who received the congratulations of the meeting on his F.R.S., gave an address summarising the recent researches carried out by the Institute in regard to such varieties of glass as (1) resistant and chemical glassware; (2) soft glass for lamp work, (3) combustion tubing; (4) glass for X-Ray work; (5) optical glass; (6) opal glass of different kinds; (7) thermometer glass.

About 50 different formulæ had been prepared by the Institute, and were available for manufacturers to experiment with.

Professor Jackson referred to the formation of the Society as an important step to co-ordinate the labours of the manufacturer and the scientist, another important matter being the formation of the department of Glass Technology at Sheffield University.

Previous to the meeting the members paid a visit to the works of Messrs. Powell and Sons, Whitefriars.

A POLARISATION FLICKER PHOTOMETER.

A contribution in the *Philosophical Magazine* for April, by H. E. Ives, describes an interesting form of flicker photometer, in which the alternate exhibition of the two photometric fields is brought about by means of a cop rotated Nicol prism. The light from the two surfaces is first polarised in two planes at right angle to each other. When the Nicol is rotated the two images wax and wane in quadrature, each becoming bright as the other fades away.

As a result the stimulus follows the cosine law closely. This enables the author to investigate the theory of the instrument, and to deduce quantitative relations justifying the accepted views of the function of photometers of this class.

INSTITUTION OF GAS ENGINEERS.

Annual Report of the Council.

The Annual Report of the Council of the Institution of Gas Engineers contained a series of references to various important researches carried out during the past year, notably through the Committees on the Life of Gas Meters, Refractory Materials and Gas Lighting, Heating and Ventilation. The Institution is also represented on the Board of Scientific Societies, the British Association Fuel Economy Committee, the National Gas Council, and other important bodies.

The Report also contains *in extenso* the Draft Standard Specification on Streetlighting prepared by the Joint Committee composed of representatives of the Institutions of Gas and Electrical Engineers, the Institute of Municipal and County Engineers, and the Illuminating Engineering Society, which it is hoped will be found useful when methods of streetlighting are reviewed after the war. In this connection a statement of the minority of the Committee is presented, expressing the view of the Council of the Institution of Gas Engineers that contracts for streetlighting should be based on the average candle-power of light sources ascertained at two or three different angles.

This Report was presented at the Annual Meeting of the Institution this month, when the President, Mr. A. E. Broadberry, gave the customary address. Reference was made to the important step taken in the formation of the National Gas Council, whose work, in many directions, will supplement that undertaken by the Institution.

EFFECTIVE SHOP-WINDOW LIGHTING.

An article by H. W. Mather in the *Electrical Review and Western Electrician* discusses some of the fundamental points in shop-window lighting. It seems to be now agreed that as a rule the best place for the main lighting is the top edge of the window. Proper reflectors, selected according to the depth of the window, are very important, and the background should also be chosen with care. It is better to avoid shiny and polished surfaces, but if these are used they should preferably not be carried right up to the ceiling; in this way one can avoid irritating direct reflections of lamp filaments, likely to be visible to persons outside the window.

Another point on which there is agreement is that shadowless illumination is not desirable. On the contrary, provisions should be made for fairly sharp contrasts. The use of lamps approaching "artificial daylight," or at least fairly white in colour, is desirable when blue-coloured goods are to be shown and there is an almost unexplored field for ingenuity in the production of pleasing colour-harmonies.

The intensity of illumination in a well-lighted window may be of the order of 10—50 ft.-candles (this, of course, applies to normal lighting conditions; considerations of economy and lighting restrictions affect the problem in this country). The specification of the consumption of energy for windows of specified dimensions is a rather awkward problem. Much depends on the type of lamp and reflector employed and the relation between depth and height of window. In the United States formulæ have been derived for windows of different size and shape, assuming the use of prescribed lamps and reflectors; in this country the problem does not seem to have yet been standardised in detail.

RESTRICTION OF SHOP AND SIGN LIGHTING.

The following Order has been issued under the Defence of the Realm Regulations, dated May 22, 1917, prohibiting the use of lights of certain descriptions for purposes of advertisements of display:—

(1) All lights of the following classes and descriptions shall be extinguished and such lights shall not be lighted at any hour except as provided in paragraph (2) hereof—

(*a*) Sky signs, illuminated facias, illuminated advertisements and other lights used outside or at the entrance to any shop or place of amusement or any other premises for the purpose of advertisement or display;

(*b*) Lights used inside any shop for the purpose of advertisement or display when the shop is closed for serving customers.

(2) This Order shall not apply to any public street light or any other light approved by the Chief Officer of Police as necessary in the public interest.

(3) The expression "shop" in this Order has the same meaning as in the Shops Act, 1912.

This Order shall apply to the whole of England and Wales and shall take effect on and after the 29th May, 1917.

This Order may be cited as the Advertisement Lights Order of the 22nd May, 1917.

IMPERIAL MINERAL RESOURCES BUREAU.

A Bureau with the above title is to be formed in London to survey the mineral resources of the Empire and their development. We understand that a scheme for the establishment of the Bureau is being prepared by a Committee appointed by Dr. Addison, Minister of Munitions.

TOPICAL AND INDUSTRIAL SECTION.

[At the request of many of our readers we have extended the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]

INDUSTRIAL FITTINGS FOR HALF-WATT LAMPS.

In an illustrated article in the *Beama* journal Mr. H. C. Wheat recently described a number of standard modern fittings for use with half-watt lamps, especially in regard to industrial lighting. Reference is made to the important factors of strength and rigidity, adjustment, ventilation, supports and cleaning.

The following points deserve special attention :—

Reflectors should be of the correct form for the particular service required. The shape varies not only with the different types of distribution but also with the particular form of reflecting surface required.

Centring of light source. Where variations in the position of the light source appreciably affect the result (as is generally the case) provision must be made to permit of its being centred ; also some form of indicator should be embodied in the design so as to enable ordinary persons to effect the required adjustment correctly.

Size of Reflectors and Globes should be sufficient to present an adequate surface for the reflection of the light, to ensure satisfactory diffusion, and reduce intrinsic brilliancy to a reasonable figure. Quality of glass must be such as to secure greatest possible diffusion with minimum loss of light.

The article also deals with illuminating engineering generally and contains a number of diagrams and photographs of modern installations.

The British Thomson-Houston Co., Mazda House, 77, Upper Thames Street, London, E.C., have issued a reprint of this article copies of which can be obtained on application to the company.

THE WEDGE OPTICAL PYROMETER.

This instrument, developed by the Optical Pyrometer Syndicate (Temple Chambers, E.C.), is intended to facilitate the measurement of temperatures from 500 degrees upwards.

The observer looks at the glowing material through an eye-piece and telescope attachment and sees a magnified image.

By inserting gradually a wedge-prism of absorbing glass the image can be dimmed until the colour just disappears.

This is taken as an indication of the temperature of the incandescent surface. The pyrometer is claimed to be specially suitable for annealing, case-hardening, and similar operations.

Catalogues, etc :—

Messrs. Turner Brothers Asbestos Co. Ltd. (Rochdale). Descriptive catalogue of insulating materials for steam power plants, hot-water installations, refrigerating plants, etc.

John Wright and Co. (Birmingham). Illustrated pamphlet descriptive of Wright's gas-heating cooking and heating apparatus for munition works.

Igranic Electric Co., Ltd. (London). Electric controlling apparatus, rheostats, switchgear, etc.

ANNUAL REPORT OF THE CHIEF INSPECTOR OF FACTORIES FOR THE YEAR 1916.

From the Annual Report of H.M. Chief Inspector of Factories for the year 1916 it is evident that inspectors have had a particularly arduous time since the outbreak of war, owing to diminished staff and the taking up of extra duties. Special reference is made to the work of Mr. Bellhouse, Dr. Collis and Miss Squire on the Health of Munition Workers Committee; of Miss Anderson, the chief Lady Inspector, in connection with the Welfare Dept. of the Ministry of Munitions, and of Mr. Sydney Smith in regard to the Reserved Occupations Committee.

Both employers and workers appear to be learning useful lessons from the present conditions. "It is fairly well recognised now that continuous and excessive overtime very soon produces lassitude and sickness among the workers and injuriously affects efficiency and both the quality and output of work." In one weaving factory special records were kept when the hours were increased from 55½ to 58 and ultimately to 65½ hours the output did not increase in proportion.

Inspectors also refer to the improvements made in factories with a view to raising the standard of health and comfort of employees. Instances are given of greater cleanliness, better heating, lighting, ventilation and sanitary accomodation, etc., and the beneficial results of these improvements.

A supplementary Report by Miss Anderson discusses the results of employment of women. By careful selection, women have been employed for very hard and heavy work. On the other hand it is stated "As regards health of substituted women it is difficult to estimate how far, if at all, heavy work causes physical injury, as there is no record of women who give up or their reasons for doing so." With a view to the future it would surely be very desirable for some such record to be kept, if the necessary machinery could be prepared.

MINISTRY OF MUNITIONS.

Official Photographs and Samples of Women's Work.

We have received from the Ministry of Munitions particulars of an Exhibition of Official Photographs and Samples of Women's Work, opened at the Royal Colonial Institute, Bristol, on May 30th, by the Lord Mayor.

The object of this exhibition is to demonstrate to engineering and other industries engaged on the manufacture of munitions the extent to which women can be employed upon responsible work of all kinds.

It will be recalled that a similar exhibition was held some time ago in London, and we do not doubt that in this case the display will be equally useful in showing the great variety of operations in which women's labour is being effectively employed.

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ASSURANCE CORPORATION, Ltd.
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WAR ECONOMY.

In consequence of the War, the cost of building material and labour has increased nearly 50 per cent. All owners of property should therefore increase their Fire Insurances; this they can do at little or no extra cost by taking a Fire Bonus Policy with this Corporation, and thus effect a saving of 20 per cent. of each premium.

Particulars on receipt of post card at either of the above Offices.

F. NORIE-MILLER, J.P.
General Manager.

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£250 TWO HUNDRED AND FIFTY POUNDS will be paid by the above Corporation to the legal personal representatives of any person who is killed by an accident causing material damage to the passenger train in which the deceased was travelling as a ticket bearing or paying passenger, or who shall have been fatally injured thereby, should death result within one calendar month after such accident. **Provided** that the person so killed or injured had upon his or her person, or had left at home this coupon, with his or her usual signature, written prior to the accident, in the space provided below, which, together with the giving of notice within seven days to the above Corporation is the essence of this contract.

This Insurance only applies to persons over 14 and under 65 years of age, is subject to the conditions stated above and contained in the General Accident Fire and Life Assurance Corporation Act, 1907, and holds good for the current month of issue only.

No person can recover under more than one Coupon Ticket in respect of the same risk.

Signature ....

This Coupon must not be cut out but left intact in THE ILLUMINATING ENGINEER as that, being dated, forms the only evidence of its currency.

B.T.H. "EYE-REST" LIGHTING.

A new list issued by the British Thomson-Houston Co., Ltd., contains a very complete series of "Eye-Rest" units of various kinds (*i.e.*, units facilitating illumination with the source of light concealed from the eye).

A great variety of bowls of different design for both vacuum and gas-filled lamps are shown, and we notice that tables are provided mentioning the watt-consumption per sq. foot for different types of installations and specifying the drop from the ceiling for rooms of various dimensions. By dividing up larger rooms into squares, and using the data provided, one can get an idea of the correct spacing for large interiors. It is naturally not so easy to state the illumination to be obtained from indirect installations as it is in the case of direct lighting, owing to the influence of size of room, nature of reflecting surfaces, and other factors. It would, however, be useful if a rough indication of the anticipated results could be given, thus bringing direct and indirect data into line.

Besides the pendant units, we notice several special fittings that deserve attention, such as the floor and table standards, which combine direct and indirect illumination, and the flambeau wall brackets, likewise adapted for concealed effects.

WORKSHOP ILLUMINATION.

A leaflet under this title, issued by Messrs. Siemens Bros. Dynamo Works, Ltd., contains some remarks on methods of approaching consumers with plans for improving their lighting. In many cases the up-to-date contractor may consider it well worth while for the consumer to scrap an old installation consisting perhaps of carbon lamps and shallow enamelled iron reflectors; but he is also aware how difficult it is to induce him to consent to the necessary expenditure.

The illuminating engineering movement, which aims at the education of the public in these matters, is thus doing good work from the contractor's standpoint as well as in the true interests of the consumer himself. One of the most effective ways of impressing the consumer with the advantages of better lighting is to show him a series of photographs, taken by the actual artificial light, of good modern installations. This is the next best thing to showing him the actual installation. In all such cases the "appeal to the eye" counts for a great deal.

SOME EXPERIENCES OF RUST-PREVENTION.

A booklet issued by Messrs. Robert Bowran and Co., Ltd., described the testing and application of "Bowranite" rust-preventing paint.

A laboratory test on unprotected and protected iron is described, samples being (a) exposed to weather; (b) alternately immersed and dried; (c) hung in river at half tide; and (d) exposed to acid fumes, the test in each case lasting 46 days.

The unprotected iron was much affected, a loss of weight of 33½ per cent. being noted in (c), and the plate rotted through in (d). It is claimed that with the protected metal, on the other hand, no appreciable rusting or corrosion took place.

·ELECTRICITY· The ·ACETYLENE·
ILLUMINATING
ENGINEER
·OIL· Edited by ·GAS·
LEON GASTER

THE JOURNAL OF SCIENTIFIC
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OFFICIAL ORGAN OF THE
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(Founded in London, 1909.)
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EDITORIAL.

Women in Industry.

In this number we give a full account of the discussion at the meeting of the Circle of Scientific, Technical and Trade Journalists on May 22nd, when a discussion on " Women in Industry " was opened by Mr. Granville H. Baillie (Chief Technical Adjudicator, D.A. Section, Ministry of Munitions).

The object of this discussion was to survey the work of women in industry, to gain information as to the duties for which they are best fitted, and the precautions that have to be observed in various vocations in order to obtain the most efficient results. The subject is one of immense importance both in regard to the present emergency and with a view to the future. The field for discussion thus outlined is a very wide one without entering into controversial matters such as wages, trade union regulations, etc.

The Circle was privileged to hear the views of a number of ladies and gentlemen responsible for the organisation of women's work, both in munition factories and in non-munition industries. There can, of course, be only one opinion regarding the magnificent way in which women have risen to the present emergency, and to many people the adaptability they have shown in taking up new fields of employment has been a revelation.

It is therefore natural that our minds should turn to the important problem of the best fields of employment for women, especially women of the more highly educated type, after the war is over. Miss Anderson (H.M. Chief Lady Inspector of Factories) dealt in a most sympathetic way with this question, pointing out that the utilisation of women in many industries should be regarded as supplementary to the labour of men, rather than as a permanent alternative, and indicating the desirability of finding opportunities of service which are congenial and suitable. The view was very generally expressed in the discussion that women are better fitted for occupations that demand deftness of hand rather than heavy muscular effort and constant strain. From experience obtained in chemical and explosives factories it may also be inferred that women, under proper supervision, show coolness in emergency as well as diligence and painstaking attention to detail. There should be good opportunity for the exercise of these qualities in many new fields of industry which will doubtless develop in this country after the termination of the war. In those processes which involve skilful manipulation, for example in the great textile industries, women will continue to be employed and, as Miss Monkhouse suggests, the better educated type of women would be of considerable value as lady supervisors, wherever female labour is employed on a large scale.

There are also many varieties of work, such as those concerned with the preparation of foodstuffs, clothing, laundry and millinery, which fall naturally within the woman's sphere, and we expect to see them more fully employed in all those businesses which bear directly on the comfort of the home, the care of children, and the public health. As doctors, factory and sanitary inspectors their co-operation is essential in dealing with the women's aspects of hygiene.

We also believe that educated women could, with advantage, take a fuller share in many varieties of scientific work, and we notice in the Annual Report of the National Physical Laboratory, and from Mr. Fleming's contribution referring to the experience of the British Westinghouse Electric and Manufacturing Co., Ltd., that in a considerable number of cases graduates of women's colleges have successfully undertaken work of this kind.

Women in Illuminating Engineering.

One field of work which seems to us particularly suited to women is to be found in the various forms of service covered by the term "illuminating engineering." In a very large section of the work, both in the manufacture of lamps and lighting appliances and in the distribution and application of light, the qualities which women usually possess would find an admirable outlet. Their deftness of hand had made them indispensable, even before the war, in factories devoted to the manufacture of electric lamps and incandescent mantles. The work involved in the making of fittings is also very largely of a light character which women could do, and the same applies to the making of optical instruments.

When we turn to the wider field of the applications of light in practice we find again many opportunities for the services of women. They have often gifts of tact and personality that render them very suitable for salesmanship or for duties which bring them into direct contact with the consumer. Their services in this direction could with advantage be more extensively used by gas and electric supply companies as canvassers, lecturers, and in the showroom.

In the case of gas companies, which are concerned not only with gas supply but with the maintenance of installations, the value of the assistance of women was widely recognised even before the war, and since then they have been found equal to the most varied duties. Inspection and maintenance are now very largely undertaken by women, and the writer can testify to the expertness and thoroughness which they bring to bear on the renewal of mantles and care of chimneys and globes. As demonstrators of gas lighting, heating and cooking, women of the right type have also done very well.

In the domestic field they have a unique advantage, for it is common knowledge that in the average home the lighting conditions are very largely—one might almost say invariably—determined by the lady of the house. Shades are selected to harmonise with the decorations, in general selected by the lady, and lamps must be located to suit domestic needs which are essentially under her supervision. An intelligent woman, one may safely say, is in a specially good position to appreciate the lighting requirements in a drawing room, bedroom, kitchen or any other part of the home. Through the services of women, therefore, we find the most hopeful means of solving that exceedingly difficult problem—the presentation of illuminating engineering principles in a form acceptable to the average non-technical consumer.

But the opportunities for women's services in connection with illuminating engineering do not stop here. Women already undertake the greater part of instruction in elementary and secondary schools, and already play a not inconsiderable part in municipal affairs. Their services might therefore be enlisted in the work of providing proper lighting facilities in schoolrooms. Moreover, the very fact of their having so much to do with the education of children makes them potent instruments for moulding the public opinion of the future in regard to lighting matters. Already it is the duty of teachers in schools to instil in the minds of children elementary principles of cleanliness and hygiene. In the same way children should be taught early the benefits of good lighting so that, to the next generation, the sight of broken mantles, dust-obscured bulbs and shades, and badly situated glaring lights will be as abhorrent as an insanitary and ill-kept home.

The same considerations apply to factories, where women already play a great part and will probably exert even more influence in the future, as inspectors, welfare workers, and superintendents. Similarly in the medical profession and in matters of public health women's influence in favour of proper illumination will be strongly felt. In all these cases their influence might be exerted.

In the case of the more highly educated women, we see no reason why they should not be able to do very good service as independent lighting experts. It has been increasingly recognised of late years that they have opportunities for advising on the choice of furniture and decoration, and supervising the fitting up of private houses. With their natural gifts in this direction might be combined the study of lighting problems. Illuminating engineering, after all, does not involve any technical study beyond the grasp of the well-educated woman. To a college graduate the recognition of the characteristic qualities of different types of lamps and reflectors, and the calculations entailed in light-distribution would present no serious difficulties.

Illuminating engineering, we have often pointed out, is not only a matter for the technical expert in lamps and lighting appliances. It is an essential element in domestic life and a matter vital to the health and well-being of the nation as a whole—of equal consequence to women and men.

It was for this reason that membership in the Illuminating Engineering Society was, from the formation of the Society onwards, opened to men and women alike. We hope that many ladies will join the ranks of the Society and take their share in the illuminating engineering movement.*

LEON GASTER.

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* See Form of Application and Particulars on opposite page.

The Illuminating Engineering Society.

(Founded in London, 1909.)

ANNUAL SUBSCRIPTION, ONE GUINEA.

All Communications should be addressed to:—
L. GASTER, Hon. Sec.,
32, Victoria Street, London, S.W.

Application for Membership.

The members of this Society shall be designated Members, Honorary Members, and Corresponding Members.

A Member may be anyone interested in the objects of the Society, but at the date of election shall not be less than twenty-one years of age.

Ordinary, Honorary, and Corresponding Members, may be of either sex and of any nationality.

An application for admission to the Society shall be made in a form prescribed by the Council, and shall refer to at least two Members of the Society ; or if an applicant certifies that he is not personally known to two members, references may be accepted to Members of professional societies of good standing, or to other persons whose good standing may be readily verified by the Council. If, in the opinion of the Council, further support for a Member's candidature be considered necessary, the recommendations of four existing Members shall be deemed sufficient ; but the final consideration of a nomination for membership rests with the Council. (*Extract from Constitution*, see *Illuminating Engineer*, Lond., June, 1909, p. 377-382).

We hereby recommend:—

Name..

Address..

....

Occupation, &c..

....

....

....

....

Date and Place of Birth..

Here state name in full, date and place of birth, rank, profession or business, usual place of residence and qualifications for membership of the candidate.

as a fit and proper person to become a member of the Illuminating Engineering Society.

....

....

....

*Here must follow the names of two or more nominators, one of whom must have personal knowledge of the candidate.

Date..

Nomination approved by Council........................

Date of Announcement of Nomination..............

Date of Election..

This portion to be filled up by Council.

The Illuminating Engineering Society.

(Founded in London, 1909.)

Abstracts from Constitution and Bye-Laws.

NATURE AND AIMS OF THE ILLUMINATING ENGINEERING SOCIETY.

The name of this Association shall be the Illuminating Engineering Society.

Its objects shall be the advancement of the theory and practice of illuminating engineering and the dissemination of knowledge relating thereto. Among the means to this end shall be meetings for the presentation and discussion of appropriate papers; the publication as may seem expedient of such papers, of discussions and communications; and through committees, the study of subjects relating to the science and art of illumination, and the publication of reports thereon.

Also the organization of, or participation in periodical national and international exhibitions of developments in illumination, and congresses dealing with the subject.

PUBLICATION OF PROCEEDINGS, &c., OF SOCIETY.

The Illuminating Engineer, published by the Illuminating Engineering Publishing Co., Ltd., in London, shall be the recognized official organ of the Society.

CO-OPERATION WITH OTHER INSTITUTIONS, &c.

The Council shall be at liberty to approach or to entertain and, if desirable, accept overtures from other Societies and Institutions with a view to joint discussions of subjects of mutual interest, exchange of transactions, and co-operation to secure Governmental action, for the advancement of the objects of the Society.

FEES AND SUBSCRIPTIONS.

The annual subscription (one guinea) is payable in advance. Applications for subscriptions shall be sent out quarterly by the Hon. Secretary.

I, the undersigned, desire to become a Member of the Illuminating Engineering Society, and hereby promise that, if elected, I will submit and conform in all respects to, and be governed by, the terms and provisions of the Constitution and the Bye-Laws made in pursuance thereof; provided that whenever I shall signify in writing to the Hon. Secretary that I am desirous of ceasing to be a Member thereof, I shall be free from this obligation, after payment of any Annual Subscription or arrears which may be due from me at that period.

Signature of Candidate..

Date..

WOMEN IN INDUSTRY.

(Discussion at a meeting of the Circle of Scientific, Technical and Trade Journalists held at the Hall of the Institute of Journalists, London, at 5 p.m., on May 24th.)

A MEETING of the Circle of Scientific, Technical and Trade Journalists took place on May 24th as stated above, Mr. L. Gaster in the chair.

The CHAIRMAN, in opening the proceedings, said that the subject for discussion was of extreme present importance and of great moment for the future. Mr. Granville H. Baillie, who had special experience of women's work in munition factories, had kindly accepted the invitation to address the Circle, and tell them something of the problems encountered in this branch of work. They were also honoured by the presence of experts in other fields who would deal with the employment of women in non-munition factories and other fields of industry. They had therefore a unique opportunity of comparing the information available from many different sources regarding the position of women in industry.

It was very necessary to know in what directions women had shown themselves specially gifted, what limitations and restrictions were necessary, and what precautions had to be taken in regard to women's labour. Everyone admired the part played by women since the outbreak of war, their resolute disregard of hardship, and the devotion which had led them to put forth their utmost effort in the present emergency. But it must be remembered that some of these efforts which might be made without injury for a short time ought not to be prolonged without thoroughly examining the effects produced on the health and welfare of the operators.

In the meantime it would be very helpful if information could be collected regarding the occupations for which women were best suited, and in which they could successfully participate in the future. There were many processes, such as those involved in the great textile industries and the making of electric glow lamps and incandescent mantles, &c., where women's deftness of hand and manipulative skill had proved valuable even before the war. After the war the most hopeful fields of extension for the occupation of women would lie in such processes. Another important matter for consideration was the desirable training and the suitable employment of the more highly educated women, as accountants, dispensing chemists, doctors, and largely for chemical and other scientific research work.

In conclusion, Mr Gaster said that it was not their object, in this discussion, to enter upon the political and controversial aspects of women's labour. Their intention was to elicit the facts in regard to the present position of women in industry, to find out the kind of work they were best fitted to do, and the precautions which would be necessary in the continuance of such work in the future.

It was very important for technical journalists to be well informed on these points so that the matter could be discussed in a scientific and impartial spirit and the true facts of the position correctly presented.

The CHAIRMAN then called upon Mr. G. H. Baillie to open the discussion.

MR. GRANVILLE H. BAILLIE (Chief Technical Adjudicator, D.A. Section, Ministry of Munitions of War), in opening the discussion, said that the "Dilution of Labour" came into being as a phrase in October, 1915, but the actual process had existed before it was christened. The more progressive of our manufacturers had already diluted their skilled labour up to the narrow limits then fixed, but so little had been done that the immense results that have now been achieved may fairly be attributed to the campaign of dilution that was initiated by the Ministry of Munitions. The first step in that campaign was an agreement known as the Treasury Agreement, made in March, 1915, with certain trades unions. Under this, the unions agreed to relax all practices tending to restrict production in consideration of certain conditions and pledges. The second step in the campaign was the distribution in October of the same year of a circular to controlled firms calling upon them to dilute their skilled labour, and the third step was the appointment of a body of engineers known as "dilution officers," to visit all firms and assist them to carry out the injunctions in the circular. The results of that campaign were shown better than he or anybody could describe them in the exhibition of women's work held at the Royal Colonial Institute, which was so successfully organised by the Ministry recently. The majority of technical journalists had probably seen that exhibition, and he felt sure that to anyone possessing sufficient technical knowledge to appreciate what he saw, that exhibition must have been an absolute revelation. Mr. Kellaway in opening the exhibition described very forcibly what dilution by women's work had done for the country, and his speech might fairly be summed up by saying that it had made all the difference between defeat and victory. In one respect that exhibition might be misleading. It showed that women were making nearly the whole of aeroplane engines, were grinding gauges to very close limits of accuracy, and were doing all the machining operations of the breech mechanisms of guns, and it might lead to the view that dilution by women's work had nearly reached its end. That was very far from being the case; even if no fresh field of work were touched it would be years before dilution was complete. The fact was that that exhibition was not a show to interest the public or to prove the wonders that the Ministry and employers had done. It had a definite educational purpose. The samples of work that were shown there were not samples of work that were being done by women throughout the country. They were samples of the best work done in certain of the more progressive firms, and they were brought together in that exhibition to serve as an object-lesson [illegible]s that had done less well, and those were, in fact, the majority of the firms in the country. Many of them were making every endeavour to dilute, but for one reason or another they remained behind. Others were indifferent, and the results they got were indifferent, but there were still others who were too proud to dilute, who said they had run their works for thirty years without a woman in the place and as long as they were in charge they would not have women in the place. The work of the Ministry was to help the willing, to convert the unbelieving, and to urge the unwilling. It was an immense task, and it was impossible to overrate its importance. It was a task in which the technical press could take a part, and a very important part. He would return to that later. For the moment he would discuss the question of what dilution was, because its real meaning was not always appreciated.

The question even now was often put, "How can a woman after a few weeks' training replace a skilled man who has taken five years to learn his job?" The answer to that was that she did not replace the skilled man in the sense of being his equal as an asset in the shop. Nevertheless, she might take his place at a particular bench or a machine without any loss of output. That was secured by reorganisation of work to make it suitable for women after a short period of training. This reorganisation of work constituted the main part of dilution. He would give an actual example, which was interesting as being about the simplest engineering job one could imagine, viz., drilling the small holes in fuses. Normally that work would be done by skilled drillers who would grind their drills, fix them and the fuse in the machine and operate the machine to drill the hole. With the high accuracy that the work required it was not by any means an easy job, and it would take a long training for a woman to tackle it. The procedure to effect dilution was as follows: The work is split up into three parts. Part 1 is grinding the drills; that is a skilled job. Part 2 is setting the drill and the work in the drilling machine so that the hole might be drilled in the right place and in the right direction and to the right depth; that entails measurement to fine limits and is also skilled work. Part 3 is pulling down the lever of the drilling machine, and that requires no skill, but only a certain amount of experience to be able to make the hole as quickly as possible without breaking the drill. Supposing there were originally ten skilled drillers and ten machines, the first step in dilution would be to put on ten women to do the last part of the job, *i.e.*, operating the machine. No training is required; they could start work at once, only for a few days the output would be low. One of the drillers is kept to set the drill, and the work for all the women, and another is kept to grind the drills, so that then eight skilled drillers are replaced by ten women, leaving the eight drillers available to obtain the output of forty additional women. The next step in dilution is that the women are watched to find the one showing the most aptitude for the work, and she is encouraged gradually to set the drill and the work under the man's supervision. When she becomes proficient in it she replaces the man who sets for the other women, so that then, without waste of time in training, nine skilled drillers are replaced by eleven women. That is a case of dilution by specialisation of work and nine-tenths of the dilution in the country to-day has been effected in that way. The example he had taken was a single one, but in many cases the re-organisation work required to specialise it and to make it suitable for women was far from simple. Sometimes new methods had to be adopted and sometimes new machines brought into use, but what was always wanted was initiative and ability on the part of the employer. When there was the will to dilute combined with the ability, then the results seen at the exhibition were obtained.

He was dealing at some length with this aspect of dilution, *i.e.*, specialisation, because he believed it had an important bearing on the development of industry after the war. Specialisation, however, was no new thing. It had been a feature of machine shop evolution in the past. In the early days there were mechanics who could see every operation on a job through. Now, in some districts, the apprentice turner would protest vigorously if his employer suggested that he should do a bit of filing; that was specialisation. Then we now had special machines and special men to operate them. There were millers, planers, shapers and slotters each working their own machines and no other. Lathes had been divided up into centre lathes, capstan and turret lathes and even special makes of lathes, each with its own operator. It was the increasing complexity of engineering work that made this specialisation an absolute necessity, and, in order to get accuracy of work and output from the average man, the man's range of occupation must be strictly limited. Before the war the change was slow and gradual, but the need for dilution had forced the pace, and specialisation had progressed as much in the past two years as it had done in the previous twenty years. We must confess, however, that the point reached had already been attained by American factories. American employers had the incentive of big outputs, and they learned specialisation when large output made the need for it obvious, and, having learned it, they applied it to small outputs. In a few factories in this country, generally under American management, specialisation had been carried to great lengths. There was one extreme instance, the erection of the Ford car on a conveyor. In that works it was one man's job to insert the split pin in the near front wheel axle and it was another man's job to insert the split pin in the off front wheel axle, and specialisation could not go further than that. Generally speaking, however, British machine shops managers before the war had no conception of the advantages to be reaped by specialisation in economy, in output and accuracy of work. Now, dilution had forced them to specialise, often much against their will, but those who could profit by experience would never need forcing again.

What he had said about women's work was, he feared, somewhat derogatory to them. He had emphasised the need for specialisation to make the work suitable for unskilled hands and he had suggested that women were doing the unskilled parts of the work. In nine-tenths of the work that was true, but in the remaining one-tenth it was far from being the case

The aeroplane engine cylinders and the ring and screw gauges shown at the exhibition were done by women who had attained a very high degree of skill, and we must acknowledge the undoubted fact that there are now many women doing work after a few months' training which ordinarily would not be entrusted to apprentices after two or three years' training. In fact, there were now many women who had accomplished what any engineer would have declared to be impossible in the time. The reasons for this were worth looking into. In the first place, the women, if fairly well educated, were much better workers than the boys. The woman was more industrious, more conscientious and more intelligent, and took a keener interest in her work. In the second place, where the work required high accuracy woman had a natural advantage over the male. She had a delicacy of touch that a man could acquire only after long training. That was proved by the fact that in certain jobs requiring extreme delicacy of handling women alone had been found able to do the work. A notable example was that astounding piece of mechanical work, the fuzee chain. Some 150 years ago every watch had a fuzee chain, which was made by hand, and the fuzee chain of a small watch, consisting of some 600 or 800 barely visible parts, appears an impossible thing to make. It was actually made by girls, and he believed it proved impossible for men to make them. The last reason was the most important. It was that the women had been taught, whereas the apprentice was not taught. The apprentice had been merely allowed to pick up what he could and occasionally get a tip from the nearest man when he was at a loss. A friend of his had told him that there was one job he believed he could do better than anyone else in the world because he had spent three months of his apprenticeship doing nothing else, and that was carrying armature coils from the varnishing room to the drying room. That gave an idea of the alleged teaching that the apprentice got. In fact, the apprentice had too often been regarded in the past by the employer as a cheap form of labourer or handyman. Women, however, were a more expensive form of labour, and the employer during the war wanted output from her and output as quickly as possible, and so he really taught her, and what women had managed to accomplish as the result of this teaching had been quite astonishing.

The dilution of skilled labour did not necessarily, however, mean dilution by the employment of women. Men and boys could be the diluent, and in some occupations they must be. The Ministry of Munitions, however, had always pressed for the employment of women. He said pressed advisedly because in many cases the pressure required had been very great. At the start of the dilution campaign a violent prejudice against women in machine shops was the attitude of most employers. They were ready to dilute with men and boys but not with women. The Ministry advocated women in place of men because men were wanted for the Army or for work which was unsuited for women, and in place of boys because many of the occupations were what were known as blind-alley occupations; occupations in which the boys learned no trade that would be of benefit to them after the war and yet got high wages, which the local police court showed were no benefit to them during the war. At the present time the Ministry advocated women in place of either boys or men over military age because it was found by experience that women acquired skill far more rapidly. He could recall no instance in which a boy or an older man had, after a year's training, reached any considerable degree of skill, but there were many employers now who would undertake to train women in that time for almost any kind of skilled work.

Coming to the present difficulty of the Ministry. Women were already employed on the easier tasks connected with machines for shell fuses and grenades. What remained to be done was to extend dilution to the more difficult repetition work, such as tool setting for shells and fuses, on the repetition work which required high accuracy, such as aeroplane engines and gun parts, and finally on work which is not done in such quantity that women can be confined to a single operation. In all these classes of work certain of the more progressive manufacturers had shown that women can be employed with complete success, and the work that lay before the Ministry was to induce all firms to comply with the standard set by the few. He had already mentioned some of the difficulties standing in the way. One was that not every firm had the ability to carry dilution very far. That must be regarded as insuperable. Another was that the will to tackle the problem was lacking. This was not generally due to want of patriotism. As a body, British manufacturers had responded magnificently to the calls made upon them in the interests of the country. It was due rather to an honest belief that dilution was impossible or else that it would so decrease the output that nothing would be gained by it. That was a difficulty that could be got over by spreading all over the country the knowledge of what dilution had effected in every class of work, and that was what the dilution officers of the Ministry were endeavouring to do. They had the facts at their command, and their duty was to persuade Jones and Co. to do what Brown and Co. had done. The exhibition at the Royal Colonial Institute and the exhibitions in the provincial centres were another means to the same end. There was yet another means which had not been tried. The position was this. The Ministry had got "the goods" as our new ally would say. So far it had travelled in them and exhibited them, but now it wanted to advertise them, and that was where he hoped the technical Press would give the Ministry help. The technical man had no faith in the lay Press when it touched technical subjects, but he was always ready to study and profit by articles written in his own language by men who knew their subject, and if the representatives of the technical Press would join in this campaign and would study the subject of dilution, he could promise them that they would find it a subject of most absorbing interest, and would find it in their power to give a very great deal of good to the cause.

At this point the CHAIRMAN referred to the considerable number of letters that had been received from various ladies and gentlemen prominently associated with the matter under discussion, expressing interest in the meeting and regretting their inability to be present.

Among others, letters had been received from the Prime Minister, the Ministers of Education, Labour and Munitions, Viscount Haldane, Sir Geo. Newman, the Rt. Hon. Arthur Dyke Acland, Sir Robert Blair, Sir James Yoxall, Dr. F. Heath, Mr. Harold Cox, Mr. H. G. Wells, Lady Parsons, Mrs. Sydney Webb, Mrs. Tennant, Miss Mary Macarthur, and Mrs. Garret Anderson.

The Chairman also read extracts from letters from the Rt. Hon. Arthur Henderson and Dr. Chas. Carpenter. The former remarked that the subject was one of such importance and required to be looked at from so many points of view that no message he could send would deal with it adequately. Mr. Henderson also expressed a desire to see a report of the proceedings when issued, as he felt sure that valuable results would accrue from the discussion.

Dr. Charles Carpenter (Chairman of the South Metropolitan Gas Co.), after expressing his regret at being unable to attend, said: "We have gone, I think I may say, at least as far as any gas undertaking in the employment of women in the industry. The surprising thing to me is the manner in which they have adapted themselves to the requirements, or perhaps it would be more correct to say how we have been able to select suitable women for our various directions with which the public is familiar. But we find that they can be trusted with a very large proportion of retort house labour which we invariably in the past associated with the sterner sex."

The Chairman then called upon Miss A. M. Anderson (H.M. Chief Lady Inspector of Factories) to continue the discussion.

Miss A. M. ANDERSON, while expressing her own private views and experiences, spoke nevertheless from the point of view of a responsible officer of the oldest department concerned with the administration of the law relating to factories. That law was the outcome of the last great industrial revolution 100 years ago, and sprang from the urgent need of protecting from injury, first the children and then the women who were drawn into large-scale production in industry by the wonderful invention of power-driven machinery. In the mere fact of productive labour by women there is nothing new; but before the industrial revolution of the 18th—19th century they worked in England chiefly under the domestic system; during and after it they worked increasingly as independent wage-earners. In the two greatest of their industries, textile and clothing manufacture, they bore their full share of skilled operations. Out of 2,000,000 women and girls in factories and workshops before the war these trades absorbed 1,178,000. In the engineering and metal trades, except in the lighter branches, women played, before the new industrial revolution which began in the events of 1914, only a very subordinate part.

2. In the first stage of the war, before the necessity for the enormous output of munitions was recognised, women played already an indispensable part in keeping the greatly expanding Army and the Navy equipped and supplied in cloth, clothing, metal and fabric equipment, rations, tents, and surgical dressings.

3. Then, *in an intermediate stage of the war*, came the need for the release of more men for the Army. Early in 1915, at the request of the Army Council, the Home Office and the Board of Trade instituted a series of Trade Conferences of employers and employed to consider how these men could be replaced, either by men of non-military age or by women. The chief problems arose over the suspension of recognised trade union rules and customs, but the conditions of employment suitable for women in new processes had also to be settled. Agreements were secured in a number of trades, including hosiery and other textiles, leather trades, print, bleach and dye works, wood-working, baking, earthenware and china, glove-making, &c. Emergency Orders were made by the Home Office allowing, under safeguards, modifications and relaxations of Factory Act rules; and women successfully undertook work entirely new to them, both in trades for which there were no special agreements and in those where agreements were necessary.

In flour milling, rubber manufacture, tanneries, oil and seed cake mills, sugar refineries, paper-making, gas works, soap and candle works, cement works, large chemical works where no agreements existed, factory inspectors guided the course of replacement. They asked for and generally obtained, especially from employers in the trades which women had not entered before, welfare conditions necessary to protect them, and they advised as to reorganisation of processes. Both the employers and the inspectors have paid great tribute to the adaptability and natural skill, as well as the patriotic spirit, of the women.

4. In the *third stage of the war* came the extraordinary development in the foremost munition industries, in the engineering and metal trades, the account of which has just been unfolded. The technical and economic aspect of this development has been fully described by Mr. Baillie, but the social and national aspect is equally important. Wide choice of skilled occupations with access to training are good for women as for men, and measures against sudden or long unemployment for women when peace comes are also essential. But it is another thing to try so to organise industry as practically to compel greatly extended employment of women in all great industries. Economic and social ills still remain from the last industrial revolution which might have been averted by earlier recognition of the labourer as more than a wealth-producer.

5. War has shown us plainly that labour is a *social function*, a national concern, that not only its products but its conditions affect the whole community, and that wealth and welfare are in fact interdependent as well as etymologically akin. It is good to know that in great emergencies women can make battleships and guns, or that they can earn men's rates of pay. But not in these things is their best ministry to the life and happiness of the nation. New and wider care of health, especially in infancy, childhood and adolescence, should make claims on women in the future on a scale undreamed of in the past. And though it may be possible to economise woman-power by simplifying the machinery of domestic life, there will still remain women's primary claims of home and

motherhood and the spiritual care of the race. Women, like men, are greater themselves than anything they can produce in the way of national wealth.

Mr. S. R. CHICHESTER (Explosives and Chemical Department, Ministry of Munitions): Mr. Chairman, Ladies and Gentlemen, I am afraid my remarks will be limited to a rather narrow field, as I have been dealing with explosives and chemical factories only. There are, however, some points peculiar to that class of factory which may prove of interest.

When I first undertook this work sixteen months ago my feeling was that there was not much scope for the introduction of women into such places. My opinion, however, has gone through a process of gradual but complete conversion, and I am now convinced that the only limit to the employment of women in such factories is where the labour conditions are such as to place the work beyond a woman's physical strength.

On first approaching the management of firms as to this matter I found they were in nearly every case prejudiced against the proposal by preconceived ideas. Their objections to the introduction of women can be placed under four heads.

1. First, danger—subdivided into (A) danger to the factory, and (B) danger to the women.

1(A). The fears of danger to the factory proved quite illusory. For the delicate operations, of which there are many in an explosives factory women are eminently suited, being more light-handed than men. They can also be relied upon to be just as careful, especially at the present time, when the women can be selected from a far wider field than is the case with men.

A particularly interesting example is the case of one of the filling factories where women are not only employed in all operations in connection with fulminate of mercury, recognised to be about as dangerous a substance as any other, if not more so, but the whole section is under the charge of a woman who told me that twelve months before she had been a nursery governess.

Then, again, a somewhat relevant point in connection with this question is the very small number of women or even the entire absence of women from those factories where there have been big disasters. It is apparent, therefore, that the employment of women has not tended to disasters of this nature.

1(B). Danger to the women. With regard to the question of danger to the women, this objection is doubtless due to the innate chivalrous feeling of men. But these are special times, and women have shown themselves only too ready and anxious to bear their share. Moreover, the dangers from explosions and poisoning have been very greatly exaggerated and can be greatly mitigated by taking proper precautions.

A particularly interesting case was one at a factory where no women have been introduced on to new operations since the start of the war, and where there was considerable opposition to such a suggestion, and yet at this very factory women have been employed successfully for 24 years on the most dangerous operation in the factory.

2. With regard to the second objection, anticipated moral difficulties, especially in the case of employing women on the night shift. These fears have proved practically groundless. The essential point in this matter is to provide for proper supervision by a female patrol.

3. The third objection is one very frequently urged, to the effect that women were no good in an emergency.

The best contradiction of this was given me recently when, on discussing the pros and cons of the employment of women at a factory where dilution was already very fully carried out, and yet where it was hoped to extend it further, the works manager said, "Well, women have proved themselves better in an emergency than men." This I must admit surprised me. On asking for details to support this view I was told that recently when a fire started in one of the drying stoves all the men in the factory bolted to the office which was in the most remote corner of the enclosure, and stood there at a safe distance and witnessed the foreman, the only man who kept his head, and the women, who were employed in the stoves, putting out the fire. On another occasion in the same factory a small explosion occurred and blew out the side of a cascade, thereby exposing the furnace. There were no women employed in this section and the men employed there at once cleared out—the one exception being the foreman, who went across and collected the women on the dry-end, who brought their Minimaxes from the drying stoves to the cascade and put the fire out.

In another factory not very far distant from this one there had been several small fires, and the women who dealt with them effectively received a well-earned reward from the manager—the latter's only fear now being that fires are becoming too popular.

4. There is one other objection which managers are apt to raise and that is the lack of confidence in the results if women are introduced.

This is very natural in the case of those managers who have no experience in the employment of women, and there is a special point that arises here in the case of explosive factories that is not present elsewhere, that is to say, that men engaged on particularly dangerous work are very chary as regards their fellow-workers, that is to say, they have got to be satisfied that those working with them are reliable and careful. These difficulties were overcome by collecting in the first instance as much information as possible as to what women had already been able to accomplish in those cases where firms had introduced them to some extent on their own initiative, and, secondly, by endeavouring to get matters so arranged that women were always put first on to the simpler, safer operations, and thereafter a selection made for introduction to the harder or more dangerous work.

There are certain disadvantages in the employment of women. First, from a woman's point of view, work in a factory gravely interferes with home life. Moreover, the eight-hour shift, except in those cases (which are naturally absent in wartime) where only one shift is worked, has not proved the remedy that might have been anticipated owing to the fact that times of coming and going do not fit in so conveniently as those of the twelve-hour shifts.

The sole disadvantage urged by firms who have given the policy a fair trial has been that women are less regular in attendance and that, therefore, a larger proportion have been kept on the books than is the case of men. There is no reason, however, why the total pay should not be the same in such cases.

On the other hand, women have undoubtedly shown themselves keener, more readily adaptable, to changing conditions.

An interesting point is that their keenness does not appear to wear off with the novelty of their situation.

I have also frequently found cases where the women have been willing to face far more adverse conditions than the men. They have carried on through rain or snow, when the men have knocked off work. A particularly interesting case of the efficiency of women is one of a factory where at the time of my first visit no women at all were employed, and the suggestion that they should be employed was met with considerable hostility. In due course, however, they were introduced fully on to all operations on the dry-end, which, in the case of this factory, was the most dangerous end, and I then approached the manager with a view to getting them put on to the whizzing. He was not at all favourably inclined to this course at first, thinking that the loads the women had to carry were too great and that they would probaby smash up his whizzers, which are costly and difficult to obtain at the present time. But, to cut a long story short, it proved possible not only to remove every man from this operation and run the work entirely by women, but they did the work so efficiently that the night shift was eliminated, although the production was in no way reduced thereby.

I have just one further point of interest, and that is the comparative immunity of men and women from the poisonous effect of varous chemicals which they have to handle. This is a highly controversial matter, and I do not think that any decision has ever been arrived at, or is likely soon to be arrived at, but there are three points distinctly in favour of women:—

(1) They keep themselves cleaner.

(2) They are less given to the consumption of alcohol and therefore less likely to absorb these poisons.

(3) Where women are employed the hours worked are generally shorter.

There is also one other point which seems to me possibly favourable to women, though I have no medical authority to make a definite assertion, and that is, women perspire less freely than men, and so perhaps do not absorb poisons so readily through the skin.

As against this, women are inclined to take insufficient meals. A rather amusing case in point was at a filling factory where T.N.T. was handled. It was found that the women brought a bun in a bag with them and transferred the bun to the pocket of their overalls, and in the course of the morning were perpetually feeling for this bun to assure themselves that it was still there, and about mid-day had a meal of bun and T.N.T.

As regards results attained. It is a little difficult to give definite figures because you may have two factories making the same product but owing to differences of geographical position and type of plant, what is possible in one case may not prove possible in another. The locality, type of plant, and class of female labour very materially affect the result. The best dilution, however, that has been attained in the case of the chief explosives is approximately :—

Cordite, 54% of total employees are women.

Picric, 40% of total employees are women.

Filling, 93% of total employees are women.

This last was in the case of a factory where there were a good many small operations such as fuse work, &c. On the other hand, the high figure of 89·9% has been reached in a factory dealing exclusively with fairly large-sized shells.

Women are, moreover, performing all operations in the manufacture of gun-cotton and T.N.T.

To sum up, I think that the policy of dilution has been thoroughly justified by results to date, and though it has reached a stage which I for one never anticipated, I think there is still ample scope for further extension.

Miss O. E. MONKHOUSE (Chief Woman Dilution Officer, M.O.M.), mentioned a few points bearing on the efficient employment of women apart from the technical aspect of the actual work carried out. Shop organisation was of the greatest importance in the successful employment of women ; defective shop organisation had been the cause of certain failures to employ women efficiently. As an instance, a foreman appointed because of his ability to manage men was not necessarily a good foreman for women. Men generally were either too lenient or too stern with women, and although the women on occasions had refused to have a forewoman, yet it was found the best results followed from the adoption of this policy. Men were not asked if they would have a foreman and women should not be asked if they would have a forewoman. As to the type of women labour, apart from the repetition work, there was great need for women of better education and who had had some shop experience to deal with some of the non-repetition work. Also women who could hold their own in the shops to act as forewomen and charge hands. As an example of what can be done with women labour, she mentioned the case of a 9·2 shop which was quite unable to make any headway with women labour. The Ministry of Munitions sent down a woman officer, and in two months she reorganised the shop, put in women charge hands, and discharged about 30 per cent. of the women who were found unsuitable, with the result that the shop was now running very smoothly. The last point she wished to mention was the means adopted by the Ministry to help manufacturers to employ women. If firms had any difficulty in handling women labour, they were urged to apply to the Ministry for assistance where they could have the benefit of a trained organiser and also the benefit of the accumulated experience of the Ministry. Dilution officers would be placed at the disposal of firms to give advice and assist generally as to the best methods to adopt to employ women successfully. The difficulty at present was that firms did not apply until they had paid the price of experience and experiment. It must be understood that these officers did not offer advice based on their own limited experience, but on the experience of the Ministry in dealing with this subject all over the country.

Mr. ATTWOOD was emphatic upon this matter of dilution. His experience in many types of factories proved conclusively that women could be brought into our factories with excellent results provided the change over was brought about in a properly organised way.

Some employers rather shirked the problem because it meant increased trouble to them, or from the old idea that a woman could never be as good as a man, and in any case she could not possibly learn in a few weeks what he imagined it had taken the man years to acquire.

In practice all this has been found to be false. Where this matter of dilution has been faced squarely, and means sought to solve rather than magnify the problems, the company itself has derived benefit which it did not anticipate. The very fact that many of the operations had to be carefully studied in order to find out, firstly, whether they would be suitable for women, and secondly, just what was the easiest and quickest way of teaching the new-comers, brought to light many things which had escaped notice in the past. It gave many a factory manager a real insight into the possibilities of the various types of work, and he accumulated experience which will be of inestimable value when the men return once more to bench and lathe.

Where a correct study has been made of the tasks undertaken by women and proper arrangements made to train them in correct work habits, there is not the slightest doubt that they are able to carry out much of the work of men who were released for the Forces; in fact, they have done better than these men who had been allowed to jog along on "rule-of-thumb" methods.

If it has not been customary for women to work in certain factories, then their introduction brings along some new problems; but they can be overcome, although it must be borne in mind that the psychology of the woman worker differs from that of the man. However, there is a big advantage on the side of the woman, in that she is not at present handicapped by the industrial evolution through which the man has passed. The woman is looking to the future, the man has also to safeguard the inheritance gained from his past struggle.

Women workers will be found to be loyal to the management and willing to co-operate with it. They have a fine sense of justice, and so long as they are governed fairly and tactfully they give of their best. Most women will prefer another woman as their immediate supervisor, although it is well for a man to be in the background, as it were. He will be looked to as the supreme authority—for it must not be forgotten that women still look to men to take the lead. It is nothing short of remarkable to see how a group of women workers will strive to come up to the standard set them by the factory manager, when they feel that he is directing them wisely and well.

The speaker called to mind the special case of a group of women workers in a factory in Lancashire. The Government made a special request for a certain commodity in numbers much in excess of the usual output. The various subdivisions of the work were studied, the women were carefully instructed during factory hours on the best methods of procedure and in one month the same number of women increased the output threefold, their rates of pay went up 50 per cent., and the cost was reduced in the ratio of 8 to 6. Probably most employers would have increased the output by increasing the staff, but in this case the extra plant necessary for additional workers was not available, and a scientific investigation, brought about partly by necessity, found that the possibilities of the task had by no means been exhausted.

A further instance was interesting. A certain task was carried out by men in pairs. As the work was highly important it seemed at first that both men were necessary for the job, but investigation proved that one man did the highly specialised operations and the other did merely mechanical work. It was obviously quite simple to get women to carry out the easier operation and so release 50 per cent. of the men. These women were able, in a few days, to deal with their portion of the work just as efficiently as the men used to do it. But care had to be taken to train the women. It is very little use letting the women just float into the men's jobs and pick it up in much the same way as the man probably did. Someone must show her just what to do, how to do it, and then be prepared to direct her carefully and tactfully until she has acquired the correct work habits. This is nothing like so heavy a task as many imagine, and whatever trouble is taken is amply repaid by the result and the feeling that the country is being helped too. Many employers to-day are reaching out for newer and better ways of dealing with their employees. Those who have tackled this problem of dilution in the right spirit have, quite unwittingly, discovered ways and means of bringing their ideas along this line into practical shape.

A speaker here remarked that there were already in existence, in a small way, many businesses such as mills, laundries and clothing factories, where not only all the operations but all the skilled management was in the hands of women. In a case she had in mind, a convent, even the boilers and engines were attended to by women, and all the workers appeared contented and happy.

Mr. S. J. **Sewell** (Hon. Secretary, London District, Inst. of Journalists) expressed his appreciation of the remarks of Miss Anderson and his interest in Mr. Baillie's address. It seemed desirable for the Ministry of Munitions to make clear the aims that they had in view in regard to the employment of women. The term "dilution" had never seemed to him a wise one, and did not properly express the methods which Mr. Baillie had explained in the course of his address. "Systematisation" would be a better word. Dilution was an offensive phrase to many workers. He was inclined to think that a good deal of labour troubles had been caused by not making it sufficiently clear that the practices of the Ministry had been designed for the purpose of meeting the extraordinarily difficult conditions at the present time, and therefore must be considered as an emergency measure.

When the war was over we wanted the skilled workers at the front to come back and find their places open, and not taken by women. He himself lived in an agricultural village about 28 miles out of London where there were 32 girls, previously employed in unskilled labour locally at 12s. 6d. a week but now earning from 35s. to 40s. a week in a munition factory some eight miles away. What was going to happen to such girls after the war?

He thought it should be clearly recognised that the present conditions were exceptional and not to be perpetuated, and that after the war our efforts should be devoted to ensuring that women labour was more and more applied to those industries which become women, rather than to work better suited for men, but which, in the nation's interest, many thousands of women were now undertaking.

Mrs. **Arthur Webb** said that she wished someone like Lieut. Atwood would go round and try to persuade the farmers to make fuller use of the services of women. The farmer was quite willing to take women after they had been trained, but they would not undertake the training themselves, and it needed a great deal of persuasion to induce them to change their methods, and receive instructions as to how the training should be carried out.

Miss J. **Cooke** (Ministry of Labour Employment Dept.) said that the supply of woman labour was also one of considerable interest in any arrangements for dilution. In many cases it had been found necessary to transfer large numbers of women to munition areas, and the work of the Employment Exchanges had been considerably increased in this way. Great difficulties had often been experienced in persuading women to leave their homes to work in other districts, and until a connection had been established with a certain factory, so that friends and relations could go together, it was almost impossible to persuade countrywomen to migrate.

Where large munition works exist, and in consequence numbers of women have had to be brought into the area, Local Committees had usually been set up by the Ministry of Labour and the Home

Office. These Committees were usually chiefly concerned with the question of lodgings, the Secretary keeping a list of inspected lodgings to which the girls from a distance could be sent on arrival.

In one case, among others, over 1300 women had to be housed in the West of Lonodon within a month The Committee had also frequently undertaken outside recreation, clubs and general welfare work.

At this stage the Chairman stated that the time available for discussion was nearly exhausted and expressed the hope that any present who wished to toke part would send in their remarks in writing.

Captain SCOTT-HALL (*communicated*):—It cannot be questioned that we are living in an epoch-making age, and when the history of the war comes to be written, the part that women have played will form no unimportant chapter. They have helped us to overcome the shortage of labour in a most unexpected manner, and have proved themselves capable of work which, before the war, we should have hesitated to believe it possible to entrust to them.

It has been my privilege during the past eight months to work in an explosives factory, in which 3,500 women were employed. Let me describe some of the operations undertaken by women; I will begin with the Gun Cotton Section.

Here, we have women handling the cotton waste from the moment of its arrival at the railway siding. They unload the trucks, handling the heavy bales, weighing from 5 to 6 cwts., by means of overhead runways, distributing them to the bale breaking room, where other women take them in hand, removing the iron bands, and placing the cotton in the bale-breaking machine. They are engaged in the teasing room, superintending various operations, including the drying. They haul the cotton to the nitrating house by hand, and perform all these operations under the charge of forewomen, and without the assistance of men. On its arrival at the nitrating house, they place it into pans, and carry out the dipping, a process somewhat difficult for women, owing to the nitrous fumes issuing from the pans. At this stage they wear respirators. From the nitrating house by means of more overhead runways, they distribute the nitrated cotton to the vat house, where they undertake the boiling and washing. The next stages are the breaking up of the gun-cotton into pulp by machinery, working the pressing machines, and finally packing in boxes. Here the assistance of men was required in removing the heavy boxes to the magazines, but a scheme was set on foot shortly before I left which will enable even this work to be done by women. So from start to finish in the manufacture of gun-cotton, each process was undertaken and carried through by women, with the oversight of the chemist in charge.

Women were also employed in the boiler house. It is true that there were mechanical stokers, but at times women did raise heavy shovelfuls of coal, shoulder high, and feed the boilers. Women control the feed, watch the temperature of the feed water, and attend the boilers generally. The general labouring was done by women, who rake out the hot and heavy clinkers from large and exceedingly hot furnaces, wheeling away heavy loads of clinkers, and depositing their loads on the dumping ground outside; in short, doing work which, before the war, was universally considered men's work. Not only do these women carry out the work satisfactorily, but what is more, they like it, and even prefer it to the lighter work in other parts of the factory.

I might here mention that the type of woman was not that of the sturdy Yorkshire class. On the contrary, they were small and even diminutive, and yet quite capable of coping with the heavy work of the boiler house.

On the Acid Plant, they took their place, receiving the soda on its arrival in trucks, unloading and distributing to the kilns, and afterwards charging the retorts, placing the earthenware cover over the opening, and cementing it as well as any man ever did. They had charge of the stills, taking the tests and generally superintending the plant with the assistance of one foreman and one chemist in charge.

We next come to the manufacture of trinitro-toluol. A considerable amount of care and discretion is required throughout as the turning on of the wrong tap would easily end in disaster; but, in the opinion of one of the chemists who has had long experience in the manufacture of explosives, women are better fitted for the work than men, owing chiefly to their patience and perseverance. In the packing room they wear respirators to prevent them inhaling the dust from the dry trinitro-toluol as they weigh it and place it in bags, preparatory to its despatch in boxes. Here, again, girls screwed down the lids of the boxes in a most business-like fashion, and finally wheeled the explosives away in trucks to the magazine adjacent to the railway siding.

I should next mention the box factory, which consisted of six separate machines, all operated by women. In the first, the wood was planed, in the second, tongued and grooved, in the third, four sides of the boxes were mechanically pressed together, in the fourth the rough edges of the boxes were planed off, in the fifth the bottom of the box was nailed on by machinery, in the sixth the holes in the lid of the box were drilled to receive the screws. There was one man foreman in this box factory, and several women charge hands. On one occasion the foreman unfortunately caught his arm in the belting, inflicting very serious injury, and the only other man present at the time ran off for the doctor, but one of the women standing by at once removed some of her clothing and bound up the man's arm, until he could be taken to the dressing station. This, you will agree, showed great presence of mind on the part of the woman, and a total absence of the timidity often attributed to women in the face of danger.

To sum up generally, I might perhaps say that the women in this factory were sensibly clothed, discarding their skirts for trousers and short coats, made of warm material in winter, chiefly khaki colour, and in summer light dungarees and different coloured caps to show the sections to which they belonged. They do not object to the garments; on the contrary, they are of opinion that they are better able to do the work in them than in skirts.

Mr. A. P. M. Fleming (*communicated*): The diminution of man-power due to the war has not only affected the rank and file of workers, but has also depleted the highly trained staffs in industry. While effective steps have been taken to employ women substitutes for machining and manual operations, comparatively little organised effort has been attempted towards their employment in positions hitherto held by men of professional training. In the engineering industry there would appear to be scope for educated and specially trained women, and although for such purposes as analytical chemistry and research women have found employment, very few have entered the ranks of technically trained engineers.

To make up for the depletion of staff due to the war, the engineering firm with which the writer is connected considered carefully the employment of educated women for such work as technical calculations, drawing, electrical testing, technical correspondence, technical publications, and scientific research. It was realised that for all these functions some specialised instruction would have to be imparted over and above the university or other education that the candidate had obtained. To carry this scheme into effect, a number of university and good secondary school students were selected and placed in departments relating to these different classes of work, and at the same time some eight hours per week specialised instruction was given during working hours in subjects relating to everyday work. Due to the probability that only a few such women will stay in industry all their lives, the character of the training aimed at making them specialists instead of all-round engineers. During the past twelve months upwards of sixty women have been selected and trained in this way, and thus far the results are satisfactory.

In view of the fact that for some years to come the supply of technically trained men from the colleges and universities will be very small, it is to be expected that women thus trained will establish themselves permanently in the higher positions in industry, and will be an important asset when the time comes for keen competition for the world's markets after the war.

Mr. J. S. Dow (*communicated*) :—The position of women in industry after the war will be a very important problem. It seems to be generally agreed that their employment for heavy and taxing varieties of work should be regarded as only a temporary expedient. After the war their assistance will doubtless be diverted into fields best suited for their natural gifts, and it would lighten the difficulties of the coming transition period if these special fields of work could be thoroughly surveyed beforehand. Light agricultural, horticultural, and dairy work, clothing and textile industries, the making of electric lamps, incandescent mantles, and optical and scientific instruments have been mentioned as suitable employments. In many sections of engineering work the fine operations requiring delicacy of touch might be allotted to women. Such work should be sectioned to avoid overlapping of male and female labour.

We must look to the new industries which we hope will develop in the future to provide new channels for the employment of women released from munition factories.

The idea that women are only to be relied upon to do all the tedious and routine work, leaving the more interesting and constructive work to men, will also have to be abandoned. The war has banished many misconceptions regarding the limitations of women. Although domestic duties will naturally be a bar to many responsible positions where continuity of service is vital, there will nevertheless be many opportunities for educated women. I have always held the view that women could do a great deal to provide the rank and file of scientific workers, sadly lacking in this country in the past. In such work their peculiar patience, neatness, digital dexterity and attention to detail would often be valuable. A short time ago I heard an encouraging account of the use of women in a factory where very intricate chemical analysis of the rare earths was being done. Here the qualities referred to above were strongly in evidence, and in several cases there was initiative as well. The line from Tennyson's *Princess*, " But when did women ever yet invent ? " has often been quoted against women. It might be added, " When did women ever have the opportunity or inducement to invent ? " In this sophisticated age it is apt to be forgotten that necessity is the mother of invention, and that the latent originative faculty is only aroused by suitable education, training, and subsequent responsibility.

The training of women for specific vocations is one of the most important problems for educational reformers to consider and even in the present circumstances the ground might be surveyed as a preliminary to future action.

Miss A. A. SMITH, in a written communication, expresses her regret at being unable to be present at the discussion, and refers to the good work being done by women in engineering shops at Plaistow. This is also one of the few districts in which women are driving electric cars. They have acquitted themselves well in this work, and the Corporation is engaging an increasing number of women drivers.

A vote of thanks to Mr. Baillie and the other representatives of Government Departments who had taken part in the proceedings was moved by Mr. GILBERT WOOD, and seconded by Miss L. E. PATTERSON (Chairman of the Women's Sub-Committee).

Mr. GILBERT WOOD, in proposing a vote of thanks to Mr. Baillie, mentioned the treatment of apprentices referred to briefly by Mr. Baillie. He had for many years felt very sadly on this question of apprenticeship ; there was no doubt that under the old-fashioned apprenticeship the boys were not always very kindly treated. Laws had to be passed to protect him, but there were also penalties which were enforced against the apprentice if he did not carry out his work properly. He would be very sorry in the present state of labour in this country and the magnificent work we generally had from labour, and the splendid co-operation of the union leaders during the war, to say anything that could possibly be supposed to hurt their feelings, but the fact was that the apprenticeship system had been largely killed by the trades unions. It had been suggested that the employer would be glad if the apprentice always remained an apprentice at 7s. 6d. per week or something like it. That had not always been the case, and he had known many works where it had not been the employer's view in any sense of the word. It was the trades unions that objected to the apprenticeship system, not perhaps officially, but some members occasionally adopted a system, by which the apprentice instead of being taught his work, was initiated into the limitation of output, and some other undesirable ramifications of present-day trades union principles. The hopes of the future of this country's prosperity will largely turn on the question of our ability to show the quality of our craftsmanship, and the quantity of our output, and a loyal understanding between employer and employee. In proposing this vote of thanks to Mr. Baillie, I should like to include the names of those ladies and gentlemen who have been present to-day, and who have given us such satisfactory and interesting accounts of their experience of women labour in our works and factories.

Miss L. E. PATTERSON, in seconding the vote of thanks, said that she had listened with interest to the discussion, but would like fuller information as to the prospects of women now engaged in munition work after the war. She had been somewhat surprised at the continued demand for women's services in war work, and it was very important to know what opening there would be in the future for women in the industries they were now entering. Many of them would not be content to return to their old dull and useless lives.

The discussion was terminated by a vote of thanks to the Chairman.

EXHIBITION OF WOMEN'S WORK AT LEEDS.

The series of exhibitions of women's work that is being arranged by the Technical Section of the Labour Supply Dept. of the Ministry of Munitions was continued by an Exhibition at the City Art Gallery, Leeds, of Samples of Women's Work on July 9th.

The exhibit consisted both of examples of work actually made, and of photographs of women making them, and was divided into fourteen groups.

A great variety of work was shown, including engines for aircraft, motor-cars, and "tanks," steam engine parts, gauges and dies, cutters and test-pieces of various kinds, small parts of Lewis and Vickers machine guns and Lee-Enfield rifles, and projectiles. A specially interesting section was that devoted to optical munitions and glassware such as gun-sights, periscopes, binoculars, range-finders, etc., the instruments being shown in all stages of manufacture, from the rough glass upwards.

PERSONAL.

At the Annual Meeting of the Royal Society of Arts on June 27th a cordial vote of thanks was proposed by the Chairman (Dr. Dugald Clerk, F.R.S.) to Sir Henry Trueman Wood for his work as secretary of the Society during forty-five years. Sir Henry, after this long period of distinguished service, has intimated his intention of resigning next September, when he will be succeeded by Mr. G. K. Menzies, who has been Assistant Secretary since 1908.

Mr. Charles F. Lacombe, who has been in practice as a consulting engineer in New York for the last few years, and was formerly Chief Engineer to the Dept. of Water Supply, Gas and Electricity in that city, has accepted a commission as Captain of Engineers in the Second Provisional Regiment 15th Co., at Plattsburg, N.Y.

Mr. Lacombe is well known to our readers as an expert in street lighting, and his professional experience will dobutless be of considerable service in his new work.

INDUSTRIAL RESEARCH IN THE UNITED STATES.*

By A. P. M. Fleming.

This paper is the first of a series to be issued by the Advisory Council on Industrial Research. Mr. Fleming summarises his observations during his recent visit to the United States, a useful feature being the inclusion of a number of reproductions of photographs of typical American laboratories and institutions. A number of suggestions are also made for the development of industrial research in this country.

Fig. 1.—The Mellon Institute of Industrial Research, containing upwards of 30 laboratories and employing about 70 salaried research workers.

Industrial research in the United States may be classified according to whether it is undertaken by: Manufacturing Corporations (companies), Associations of Manufacturers, Universities and Colleges, National Institutions, Commercial Laboratories, and Scientific Societies.

The Report contains a brief description of 21 industrial research laboratories, 13 examples of University Research, 6 National Institutions, and 7 Commercial Research Laboratories. In many cases the expenditure on research work is very considerable. Thus the Eastman Kodak Co. spends for this purpose about £30,000, or 0·7 per cent. of the annual profits, and the General Electric Company from £80,000 to £100,000 per annum.

Among the most striking features of the research work undertaken are :—

(1) The installation in many cases of full scale manufacturing facilities which enable works to be relieved of experimental development, and ensure that inventions can be tested on a practical scale before manufacture for sale.

(2) The provision of facilities to enable any new discovery in the works to be taken up at the stage in which the scale of manufacture calls for transference to a separate organisation.

(3) The tendency to devote more time to pure science investigations, such as may ultimately lead to new discoveries.

Other points of interest are the freedom with which results in pure science are published; the growing appreciation of the value of scientific men in the factory; and the recognition of the value of research laboratories as a means of inspiring confidence in the minds of customers. There are a number of

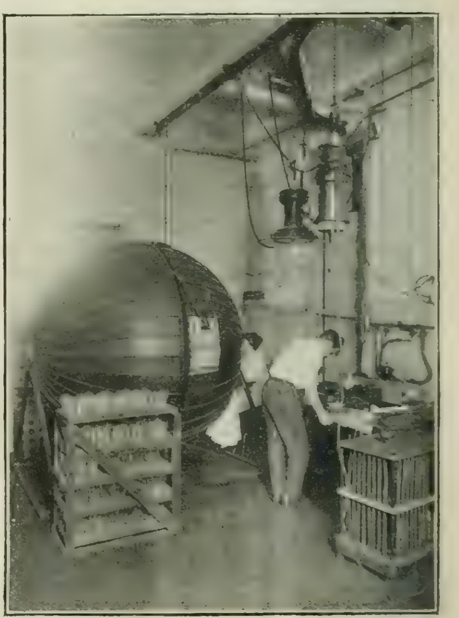

Fig. 2.—Lamp Testing Laboratory, Electrical Testing Laboratories, New York (U.S.A.).

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* To be purchased through any Bookseller or direct from H.M. Stationery Office, Imperial House, Kingsway, London, W.C.2; 1s. net or 1s. 3d. post free.

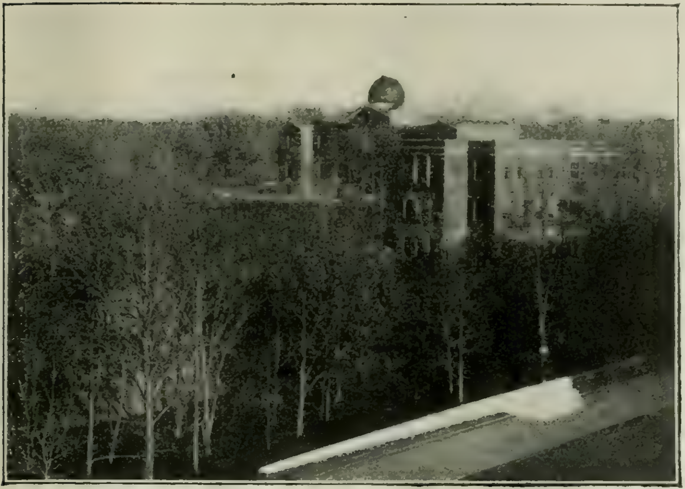

Fig. 3.—General view of Laboratories and Park, National Electric Lamp Association. This Association, which is controlled by the General Electric Co. (U.S.A.), comprises twenty or more electric lamp factories in the States. There are seven large blocks of buildings, situated in a park of 79 acres, and about one-third of the buildings and staff (numbering 600) is devoted to research. The Laboratory includes a full-size manufacturing plant for producing lamps in bulk.

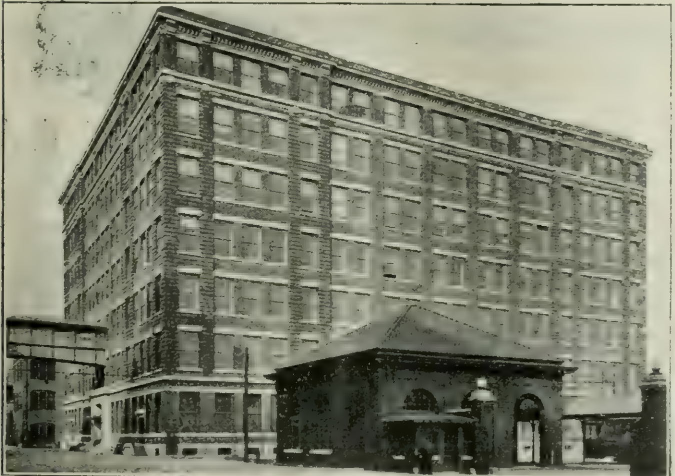

Fig. 4.—Research Building, General Electric Co., U.S.A. The Research Laboratory occupies the first five floors of this seven-storey building. The annual cost of research work conducted is now about £80,000—£100,000, and a staff of upwards of 150 is employed on experimental work.

Associations of Manufacturers which conduct research work of common benefit, either in the laboratories of individual manufacturers, in Universities, or at the Bureau of Standards. The National Canners' Association has its own laboratory.

At the Universities fellowships are often endowed by firms or scientific societies, and large-scale investigations are undertaken at experiment stations. The Mellon Institute is unique. It contains about 30 laboratories where work is carried out for manufacturers, who are required to endow fellowships for men undertaking the desired investigations. When a research nears the practical stage plant on a small manufacturing scale is often installed in order to develop the process fully before it is attempted on a commercial scale. Results of such researches are not published, except with the consent of manufacturers, until three years after the investigation.

The National Institutions, such as the Bureau of Standards, the Carnegie Institution, the Forest Products Laboratory, and the Bureau of Mines offer extensive facilities for research and their advice is freely given. Attempts are now being made to prevent overlapping of the various Research Agencies. It is widely recognised that important researches may often be undertaken by men of average ability working under competent direction. This is a point that is insufficiently appreciated in the United Kingdom.

Turning to conditions in this country, Mr. Fleming points out that the war has disclosed remarkable latent capacity for adaptability to new lines of manufacture, many of them dependent on scientific research; but the facilities for such research are at present disproportionately small.

The most important alternative schemes for the United Kingdom, as suggested by Mr. Fleming, are :—

(A) Research Laboratories in industrial works.

(B) Research Laboratories for a group of works in the same industry.

(C) The centralisation of research in the Universities and Colleges.

(D) An Imperial centralised laboratory for the whole industry.

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH.

New Address.

From July 23rd onwards the Offices of the above Department were transferred to 15, Great George Street, Westminster, S.W. The telegraphic address ("Resciendus Parl. London") and the official telephone number (Victoria 7940, 2 lines), remain unchanged.

Obituary.

The death is announced of Mr. William Wilmot, who had been associated with Messrs. Falk, Stadelmann and Co., Ltd., for the last 16 years.

Mr. Wilmot recently joined His Majesty's Forces, and while on duty contracted pneumonia which unfortunately proved fatal.

Assets exceed £2,500,000.

Claims paid over £8,500,000.

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Particulars on receipt of post card at either of the above Offices.

F. NORIE-MILLER, J.P.
General Manager.

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CORRESPONDENCE.

FLUORESCENCE AND PHOSPHORESCENCE.

June 11th, 1917.

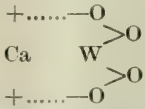
SIR,

The discussion and papers on "Fluorescence and Phosphorescence" in your March issue gives a valuable review of the physical and engineering aspects of the subject. If a photochemist may be permitted to indicate the chemical basis of the phenomena, I should like to submit a few considerations tending to the conclusion that fluorescence and phosphorescence do not simply denote a "distinction without a difference," but the time-lag in the latter has a chemical cause. Naturally in the scope of a letter I cannot enter into all the evidence, but I would point out that whilst *fluorescence*, in the sense of luminous or actinic response which terminates at once when the exciting rays cease, depends conjointly upon the chemical composition and constitution of a saturated pure compound, *phosphorescence*, response persisting subsequent to excitation, is associated with the presence of stray or unsaturated affinities due to free, usually metallic nuclei, of several valency stages, in colloidal or solid solution in the material.

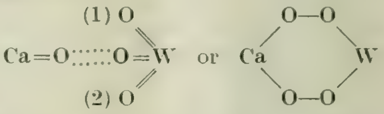
This conclusion is not, of course, new, but was established by the work of Lecoq de Boisbaudran, and confirmed and extended by Lenard and Klatt, working on alkaline earth sulphide phosphors. I have obtained evidence in the same sense working with calcium tungstate, which can both fluoresce and phosphoresce under X-rays. Briefly :—

(1) Calcium tungstate precipitated in the wet way and dried exhibits neither fluorescence nor phosphorescence. This precipitate is visibly amorphous, but under high power microscopic examination seems to be microcrystalline.

(2) Fluorescence *and* phosphorescence, to X-rays, are developed by heat treatment carried to the "sintering" point, when the material consolidates from a loose voluminous powder to a dense solid and becomes pronouncedly crystalline. It appears from this, and from other cases cited by your contributors, that the luminous response depends largely upon the development of the crystalline solid structure, but the more exact nature of the dependence will require special "crystal analysis" on the lines due to Laue and the Braggs. It seems possible, provisionally, that the first precipitated calcium tungstate formed by combination of the ions, $Ca{+}{+}$ and $WO_4{-}{-}$, consists chiefly of a *polar* compound, a "tungstate," of the type



more of less hydrated, owing to the half-free charges, and that this is metamorphosed by the heat treatment (to incipient fusion) to an anhydrous *non-polar* complex of the type $CaO.WO_3$ or $CaO_2.WO_2$*



which, singly or in group molecules united by the residual affinities of the oxygen atoms (1) and (2), form the structure units of the crystalline configuration in the denser, luminescent form. In view of the variety of combinations of the oxides of tungsten with more basic oxides, the displacement of the system either to more basic tungstates or to more acid (polytungstates) is easily possible, and must play a part in affecting both the crystalline solid configuration and the luminescence.

(3) Be that as it may, the elimination of *phosphorescence* from a calcium tungstate in X-rays, and restriction of its response to *fluorescence*, depends upon the purity and purification of the material, in particular, on the removal of *reducing* materials and conditions. It is easy to prepare tungstates having considerable amounts of the tungsten present either as a sub-oxide WO_2 or more probably as colloidal tungsten—the "tungstate bronzes" are examples of such bodies—and our work indicates that all circumstances tending to produce this partial reduction favour strong phosphorescence, and conversely. The amount of reduction product necessary to induce marked phosphorescence is extremely small, probably of the order of the "latent image" in photographic plates, and, again, with the production of visible coloration (bronzing) of the tungstate, the phosphorescence reaches a maximum or even becomes less.

Trusting that a chemical after-glow on one phase of this subject may not be unwelcome, I remain,

Yours very truly,
(Dr.) S. E. SHEPPARD.

(Eastman Kodak Co., Research Laboratory, Rochester, N.Y.)

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* As found in rutile, zircon, etc.

ELECTRICITY · ACETYLENE · OIL · GAS

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LEON GASTER

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EDITORIAL.

Progress in Industrial Lighting.

On pp. 185—189 in this issue we give a summary of some of the chief features in a series of articles on Industrial Lighting by Mr. C. E. Clewell, which have been appearing in the *Electrical World*.

Progress in industrial lighting during recent years has been very rapid. A feature has been the development of overhead general lighting, and Mr. Clewell suggests the application of this method to foundries and other workshops where it has not hitherto been generally employed.

The chief need, in order to bring home the benefits of up-to-date factory lighting, is the provision of concrete evidence of its influence on output and in diminishing accidents. Mr. Clewell mentions the case of a works which, after spending 50,000 dollars on improved lighting, caused an enquiry to be made into the nature of the ensuing benefits. A number of instances of waste and lost time, directly due to the old and imperfect lighting, were revealed. Many of them, probably, would not have been revealed but for the change to the new conditions.

Equally useful are the diagrams presented, which we reproduce on p. 187, showing actual cases of accidents traced to defective lighting conditions. Such illustrations are most useful for propaganda work. It would be most instructive if the freedom from accidents, the improvement in output, and the diminution of spoiled work following improved illumination could be computed in terms of cash, in the form of a return on the lighting as an investment. If this could be done in particular factories the results would, we believe, prove a revelation to many manufacturers. Expenditure on lighting has been shown by many investigators and is known to be almost invariably a small fraction—sometimes less than 1 per cent. of the wages bill. Mr. Clewell, dealing with the special case of motor-car shops, also calculates that the cost of installing proper lighting forms only about 3% of the total cost ot equipping a shop of given area, and in many cases we imagine it would be even less. Such figures show the wisdom of judicious expenditure on illumination.

Perhaps the most interesting section of the series of articles is the comparison of the chief " codes " and reports relating to lighting in factories. Such codes were introduced last year into the legislation of two States, Philadelphia and New Jersey, while the regulations in force in Wisconsin, which date from 1913, are now undergoing revision. The chief respect in which these codes differ from the Report of the British Home Office Committee is the inclusion of the minimum illumination desirable for various classes of work. These values, in the light of present knowledge, must be looked upon as tentative, but it is interesting to observe that, according to investigations carried out in up-to-date factories, they are well within the illumination actually provided. It is only those factories which are distinctly backward in regard to illumination which fail to come up to the required standard.

Mr. Clewell, like authorities in this country, recognises the desirability of proceeding cautiously in enforcing the provision of standards of illumination by legislation. Admittedly there are difficulties, which time will overcome, in enforcing a standard based on the provision of a certain illumination in foot-candles. But it is shown very clearly that methods based on " watts per square foot " or " candlepower per square foot " are open to grave objection on principle, and it is significant that in the State of Wisconsin the former method, which was used in the pioneering code of 1913, is likely to be replaced by values on an illumination basis.

This series of articles is timely in view of the recent recognition by the United States Government of the importance of proper methods of lighting in war time. On p. 197 we refer to a most important step, the appointment of a National Committtee on Lighting, on which the Illuminating Engineering Society in the United States, with the co-operation of the gas and electric lighting interests, is to co-operate with the Council of National Defence. The Committee is to advise on all matters relating to lighting, especially in regard to factories, mills, arsenals, munitions plants and concerns under contract to the Government, and will prepare specifications and rules relating thereto. The United States Government has acted with commendable enterprise and promptness in this matter and we feel sure that their wise decision to make full use of experts on lighting will have most valuable results.

A New Epoch in National Education.

The recent address by Mr. Fisher in the House summarising his proposals for the extension of school years marks a new epoch in national education. It is suggested that child labour under the age of 12 should be prohibited from the date of the passing of the Bill, that there should be full elementary education up to the age of 14, and that half-time and exemptions are to be abolished as from the end of the war. Continuation schools are to be made compulsory up to the age of 18 for all who have not received full time education up to 16, and continuation scholars will receive instruction for not less than 8 hours per week, part of which will be devoted to physical training. An important point is that these hours are to be set aside from the normal period of employment.

These suggestions mark a very distinct advance. The proposals will no doubt undergo some modification before the final Bill is passed, but it is to be hoped that these very moderate demands will meet with approval. Indeed many people would consider that the time allotted for continuation classes, at a time when continuance of education is specially beneficial, is hardly sufficient. A period of 8 hours a week, including physical training, does not leave much time for intellectual training. We assume, however, that Mr. Fisher has found it necessary to proceed with caution, and in the present circumstances it will be very satisfactory if the advance he foreshadows is carried into effect.

We shall return shortly to the industrial aspects of these proposed educational changes; but we would like first to emphasise the point that, apart from its material value, continuity of education is necessary also in order to produce good citizens. Everyone who has studied social problems and labour difficulties must have felt that in many cases trouble is due to inability to make sound judgments and take a wide outlook. An educated democracy is less liable to be swept away by short-sighted ideals and misguided ideas. In a more enlightened age such conflicts as that in which the greater part of the world is now engaged would be less likely to occur and might even be rendered impossible.

Finally we should like to point out that not the least valuable result of education is that it leads to a fuller enjoyment of life and a better use of leisure. A man or woman who has intellectual resources outside the daily task gets far more out of life than one whose mind is uncultivated and whose interests are narrow and few. Many of the social evils of to-day are due largely to the absence of these wider interests and the want of congenial recreation.

In the debate in the House some reference was made to the presumed hardship of parents being obliged to keep their children at school when their contributions as wage-earners are needed for the upkeep of the home. Much perseverance will be needed to dispel these ideas. The desired results must be attained without imposing undue hardship on parents who may not be prepared to meet this additional burden out of their present limited income. We believe it could be shown that more generous educational facilities would ultimately enable the children to make better provision for the support of the home and that parents who have the welfare of their children at heart would not, for the sake of immediate pecuniary gain, stand in the way of their advancement.

National Education, its Industrial Aspects.

Having dealt with the more general aspects of the reforms in education proposed by Mr. Fisher, we desire to say something on their industrial aspect. There has been much discussion recently on the relative claims of the humanitarian and industrial aspects of education, and it is fortunate that we have in Mr. Fisher a Minister of Education in a particularly good position to do justice to both these conceptions of training. As Vice-Chancellor of Sheffield University he has been brought in very intimate touch with technical education in relation to industry, yet his own broad interests and his association with such work as that of the Workers' Educational Association enables him to take the necessary wide views.

From the industrial aspect the proposed changes are of momentous importance. We have always felt that the gap existing after children have left the elementary school is one of the chief defects in the educational system of this country. This break in continuity means that early educational influences are largely wasted, that mental development is checked and that children thus tend to become mere cogs in the industrial machine. Thus while we have generals and captains of industry we lack the material for intelligent subordinate officers. The establishment of compulsory continuation schools should help to bridge this gap. Equally important will be the steps foreshadowed in the Interim Report of the Consultative Committee on Scholarships for Higher Education issued in July last year, providing for the establishment of bursaries and scholarships, not only giving free higher education for gifted children, but a contribution to their living expenses during the period of study.

Such steps would help towards removing the great obstacle to higher training of children in the poorer classes—the disinclination of parents to lose such contributions which they might be making as wage-earners to the upkeep of the home. It is equally important that both manufacturers and the State, recognising the far greater value of educated workers, should do everything possible to encourage education. Parents and children should be convinced that better education, so far from being a pecuniary drawback, will enable them to earn wages and assume positions which would otherwise be outside their scope ; and that continuation of instruction is an investment which will give a good return.

A great deal is being said of the advantage to the manufacturers and the nation of securing better educated workers. We are glad that this view is gaining ground for we are convinced that the prosperity of this country involves the provision of better education and a more lively appreciation of its benefits. Whatever the outcome of the present conflict, the future of nations depends primarily on the knowledge, skill and intellectual value of their people.

But at the same time the workers should be made to feel that educational facilities are not merely a dodge on the part of manufacturers to get more out of them. The process acts both ways. It enables manufacturers to achieve greater results and make better profits. But it entitles the educated worker to a higher wage, enables him to rise to higher positions, and adds immensely to the possibilities of life. Above all it will enable him to gain a better insight into industrial and social conditions and to bring about juster and more cordial relations between capital and labour.

LEON GASTER.

AUTOMOBILE HEADLIGHTS.

The *Transactions of the Illuminating Engineering Society* (U.S.A.)* contains a series of three papers by W. F. Little, S. C. Rogers, and E. J. Edwards, on the design of headlights and the framing of regulations relating thereto.

Mr. Little illustrates in detail a considerable number of typical lens and mirror arrangements, many of them specifically designed to minimise glare. The problem involves a compromise between satisfying the latter condition and the provision of sufficient illumination for the motorist to find his way with safety and comfort. A number of misconceptions are mentioned—such as that the lenses and mirrors *increase light*, whereas they only redistribute it. Many of the devices suggested for diminishing glare (*e.g.*, the use of rheostats, translucent diffusing screens, etc.) only do so by diminishing the light as a whole and thus weakening the illumination. They may be of service in special cases where the need for eliminating glare is accompanied by a smaller demand for road-illumination; but generally speaking the diminution of glare should be accomplished by altering the distribution of the light rather than diminishing it. The adoption of special lens surfaces, and the device of making the mirror in two sections of different foci, seem preferable in this respect.

A circular on the subject was addressed to twenty-eight men who were understood to have given the subject special consideration. The majority favoured the restriction of the main beam below the horizontal, but it was recognised that some oblique illumination of the sides of the road and of surrounding objects is also needed. As a rule the beam from a headlight need not illuminate the road for more than 300 feet ahead; it is suggested that the width of road illuminated sideways should be about one-tenth of the length of road illuminated ahead. Some observers consider that a yellow beam is less glaring, for a given intensity, than a white one.

Mr. S. C. Rogers refers to the regulations of a number of States bearing on headlights, and these are also discussed by Mr. Evans. In most cases the regulations contain general phrases such as that the light should not be of a dazzling character, which are open to very varied interpretation. The framing of precise regulations is a matter of considerable difficulty. The apparent efficiency of a headlight will depend on the nature of the road surface, *i.e.*, whether of light or dark material and, owing to the oblique illumination, glare is apt to be produced by direct reflection from a polished surface.

A difficulty in following the prescription regarding the limitation of rays to below the horizontal is that such a condition would not operate satisfactorily on roads of rapidly varying declivity and having marked irregularities in their surface.

Headlamps in use commonly give, with a parabolic mirror, from 10,000—100,000 maximum candle-power. The selection of a filament of small superficial area is essential to produce a relatively narrow beam and avoid objectionable images, and it is also desirable that the position of the filament should be capable of exact adjustment at the focus of the reflector.

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* No. 3, Vol. XII., April 30th, 1917.

THE NATIONAL PHYSICAL LABORATORY.

The Annual Meeting of the General Board of the National Physical Laboratory was held at the Laboratory on May 19th. The President of the Royal Society, Sir J. J. Thomson, is Chairman of the Board; Lord Rayleigh is Chairman of the Executive Committee.

The outstanding feature of the year has been the growth of the gauge-testing work. Nearly the whole of the gauges required for the inspection of munitions are now examined at the N.P.L., the number averaging about 10,000 weekly. By arrangement with the Minister of Munitions a new building has recently been erected to accommodate the work, the space otherwise available having become quite insufficient for the purpose. There has been a great increase also in the number of optical and electrical instruments tested for the Admiralty; a new branch of work is the testing of luminous dials for instruments of various kinds.

The investigations carried out have been, in the main, of confidential character. Aeronautics research has continued to be of great importance. The William Froude National Tank has carried out much work for the Admiralty, and has been visited by members of the Board of Admiralty—including Mr. Balfour when First Lord—who have expressed much appreciation of the results attained. In the Metallurgy Department researches on light alloys, and on optical glass, have been continued, while a number of special problems have been dealt with. Various investigations have been in progress in the Engineering Department: hardness tests, methods of impact-testing, the fatigue resistance of materials under combined bending and twisting stresses, the transmission of heat from surfaces to fluids flowing over them—as in the flow of air over an aeroplane engine—are among the questions examined. The observations on the rate of growth of cracks in the buildings of the Tower of London have been continued. No serious disturbances have been detected.

Much attention has been given recently to the question of the future of the Laboratory, and in particular to its relations with the Department of Scientific and Industrial Research, and a scheme will no doubt be arranged whereby close relations with the Department will be established.

CONJOINT BOARD OF SCIENTIFIC SOCIETIES.

The fourth meeting of the Conjoint Board of Scientific Societies was held at the Royal Society on June 13th, Sir Joseph J. Thomson, O.M., Pres. R.S., in the chair, to receive the report of the Executive Committee on the work of the previous six months.

A number of important questions of scientific and industrial importance has occupied the attention of the Board.

Interim reports were received and approved on the necessity for an anthropological survey of the British people, on the best methods for carrying on the International Catalogue of Scientific Literature, and on an enquiry into the desirability or otherwise of the adoption of the metric system throughout the British Isles.

The Sub-Committee on National Instruction in Technical Optics reported that a scheme approved by the Board of Education had now come into operation. Under the ægis of the Imperial College of Science and Technology an Advisory and Administrative Committee had been formed to organise instruction, and Mr. F. J. Cheshire, a member of the Sub-Committee of the Board, has been appointed Director of Studies in Technical Optics.

Among other matters being considered are: The publication of information being collected on the mineral resources of the Empire, magnetic disturbances throughout the British Isles and their possible connection with the presence of iron ores; the fransport of raw materials to farms and agricultural products from them, and the respective advantages of steam, internal combustion, and electrically operated machines in this connection; the amount and distribution of water power in the British Empire.

A complete report of the first year's work of the Board will be published in due course.

SCIENTIFIC RESEARCH IN FRANCE.

The *Académie des Sciences* has decided to establish a National Research Laborator nn France The laboratory is to be controlled by a Council, half of the members be to nominated by the *Académie*, one fourth by the State Department and the remainder by the chief industrial associations. Existng laboratories will be affiliated with the National Laboratories will and work in cooperation with it.

NOTES ON INDUSTRIAL LIGHTING.*

By C. E. Clewell.

Two important considerations in favour of proper industrial lighting are (1) The effect on the eyes and health of workers, and (2) The effect on the efficiency of factory management.

While it is agreed that inadequate lighting must handicap eyesight, it is not so generally recognised that the eye being in a sense the "weakest link in the chain" is particularly easily injured by strain. With advancing age the eye is one of the first organs to be affected, and exceptional fatigue, while lowering the tone of the whole body, is very apt to prejudice vision.

The fact that good lighting is conducive to improved output and better quality of work is recognised, but as yet we have not a great mass of data based on actual cases of saving due to good illumination.

How Good Lighting Saves Time.

Such a case is mentioned by the author. A firm recently expended 50,000 dollars in bringing its lighting thoroughly up to date. An inquiry was afterwards instituted and a number of instances of directly beneficial results were brought to light. For example: (a) A manager in one department stated that before the improvement was introduced it was difficult to induce the best type of man to stay; after the improved lighting was introduced there was no such difficulty. (b) A man who under the old conditions was in the habit of spending time looking for material and moving from place to place in the shop, found a great saving in this respect with the improved illumination. Presumably he could see better where things were kept, and it was also noticed that he kept the floor tidier and free from scrap. (c) A foreman stated that before the good lighting was introduced it had been found that men on the night shift would not work for the last three hours, complaining that the lights were out of order. Difficulty was also experienced in getting men to start work on dark mornings, and as much as two hours was sometimes wasted in this way. (d) It was noticed that one of the workmen often found it necessary, when making a measurement, to put his thumb on a place on the rule and then walk away to a spot under the light to read the figure. With improved lighting there was no need for him to leave his place.

Obviously all such difficulties as those referred to above have a cumulative effect in causing loss of time. Dealing with a case in which the running cost of lighting per bay worked out to 17 cents per day, Mr. Clewell calculates that it would only be necessary for a workman to save two minutes in a day of eight hours to meet the lighting cost. This is very close to calculations made by other observers. In another case where specially skilled work is involved, in motorcar work, Mr. Clewell estimates that the running cost of lighting amounts to only one-tenth per cent. of the wages bill.

Illumination as a Return on Investment.

It would, Mr. Clewell suggests, be very helpful if the advantages of improved lighting could be presented in the form of a return on investment. No doubt the return would depend to a great extent on the nature of the work and the local conditions, and at present there are few cases in which a sufficiently careful check has been made to enable such a return to be made. Experiments in certain works are now being conducted with this end in view.

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* Based on a series of articles appearing in the *Electrical World*, June 2nd, 9th, 16th, 23rd, 30th; July 7th, 14th, 1917.

ILLUMINATION DATA FOR INDUSTRIAL LIGHTING.

Mr. Clewell gives figures for gas-filled lamps and ordinary vacuum lamps approximately as follows :—

Gas-filled lamps, 9—10 lumens per watt.
Vacuum lamps, 11·5—18 lumens per watt.

He emphasises the great importance of choice of shades, and traces the steps in industrial lighting development during recent years. There is a strong tendency towards general overhead lighting. With the high candlepower lamps available this is quite practicable and has two great advantages : (1) That the lamps can be kept high up out of view leaving the room clear, and (2) That the lighting system is independent of the positions of benches, etc.

For many classes of such work one would secure good conditions by assuming the use of 100-watt vacuum lamps operating at 10 lumens per watt, and used in such a way as to give a utilisation efficiency of 40 per cent. Then with 1 watt per square foot, and 0·8 mean spherical candlepower per square foot, or ten generated lumens per square foot, one should get a uniform bench illumination of about 4 ft.-candles. Reference to the above figures for the efficiency of vacuum and gas-filled lamps suggests that with the latter illuminant one might expect, for the same consumption, an illumination 50 to 100 per cent. higher. Similar figures could readily be worked for overhead gas lighting.

FOUNDRIES AND MACHINE SHOPS.

Dealing with foundry and machine shops, Mr. Clewell emphasises the importance of the daylight factor, *i.e.*, the percentage of the unrestricted outside daylight illumination that finds its way into the shop at the place where work is done. This factor is commonly within 0·5—2 per cent., but in cases where there is reliance mainly on lateral lighting, and the interior surroundings are dark, one may find figures as low as 0·1 per cent. or even 0·01 per cent. Assuming, however, that 0·1 per cent. is realised it can be calculated that on an average December day the minimum daylight illumination will not exceed 0·75 foot-candle. At this season of the year, therefore, the provision of artificial illumination is indispensable, even throughout the day-shift, on many kinds of work.

In view of the fact that workers in foundries are constantly moving about, and that the floor is often uneven or littered with material, general overhead lighting is considered very desirable. As, however, vertical surfaces have so often to be dealt with strong side-lighting is also useful, and this may be secured by adopting reflectors with a "spreading" distribution of light.

With gas-filled lamps 0·25 watt per square-foot is a usual allowance.

The following values are suggested for foundry and shop work :—

TABLE I.

	Foot-candles.
FORGE AND BLACKSMITHING :—	
Ordinary anvil work	2— 4
Machine forging	2— 3
Tempering	2— 4
Tool forging	3— 5
FOUNDRY.	
Bench moulding	1— 3
Floor moulding	1— 2
MACHINE SHOPS.	
Assembling	4— 7
Drills	2— 4
Millers	3— 6
Planers	3— 5
Rough manufacturing ..	1·25— 3
Fine manufacturing ..	3·5— 6
Special fine work	10—15
STOCK ROOM.	
Rough materials	1— 3
Fine materials	2— 4
Ordinary storage	0·25— 5

MOTOR-CAR SHOPS.

Another case of industrial lighting discussed is the illumination of motor-car shops. The output of cars in the United States has risen from one million in 1909 to sixteen millions in 1916, and the estimated value of goods from 250 to 5,000 millions. The opportunity for proper lighting in this industry is therefore evident. It is stated that the lighting equipment of a modern factory is of the order of 50—150 dollars per 1,000 square feet. The lower figure is estimated to be only 3 per cent. of the total cost of equipment and erection. There should therefore be no grudging of the expense of proper illumination in planning a factory.

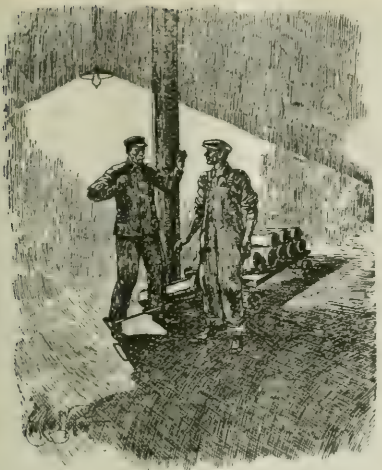

FIG. 1.—The workman pulling the truck failed to see an iron bar near the floor, which caused the truck to swerve to the right. In so doing it dislodged the truck handle from the man's grip and caused a heavy pipe to fall from the truck on another worker's leg, breaking it below the knee. Owing to the dense shadow cast by the pillar it was practically impossible to see the iron bar which caused the trouble.

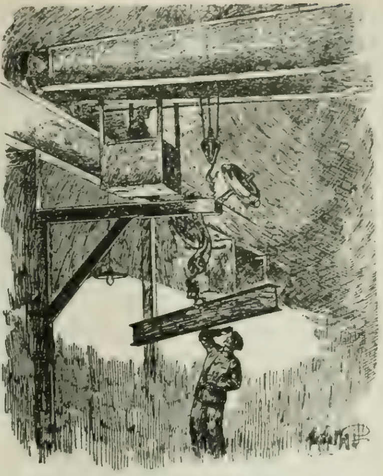

FIG. 3.—The post crane was struck by the load suspended from a travelling overhead crane and the shock displaced a steel beam, which fell and caused injuries to operators below. This shows the drawback of using only lights with opaque reflectors placed at a low level below the post crane projection, which received no light and was invisible from above.

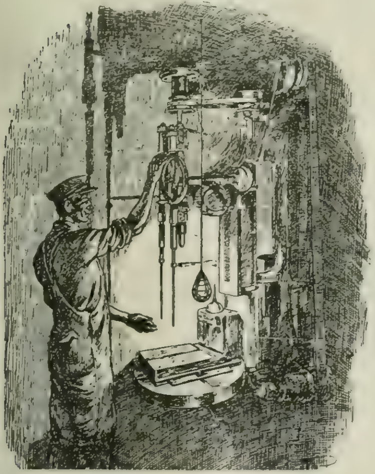

FIG. 2.—Blinded by the glare from the bare lamp over the drill-press table, the operator allowed his fingers to get within gears while reaching for the drill-press feed control.

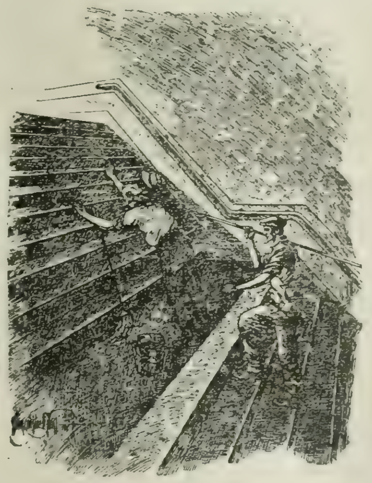

FIG. 4.—Owing to inadequate lighting the man carrying the bar failed to see the man in front of him and the latter was struck in the back of the head by the projecting iron bar.

Examples of how Inadequate Lighting Causes Accidents.

(C. E. Clewell, *Elec. World*, June 16th, 1917.)

In two typical installations described the consumption with gas-filled lamps is about 1 watt per square foot.

ILLUMINATION AND SAFETY.

Dealing with the question of safety, Mr. Clewell emphasises many of the points recently commented upon in this journal. He quotes the views of a large insurance company in the States to the effect that 23·8 of 91,000 accidents investigated might be traced directly or indirectly to inadequate lighting. It is to be noted that the Pennsylvania and New Jersey factory lighting codes both require auxiliary lighting, which is to be thoroughly dependable at all times. Some instructive cases of actual accidents due to defective lighting are described. We reproduce on p. 187 the diagrams relating thereto.

LEGISLATION REQUIREMENTS ON FACTORY LIGHTING.

An interesting review is given of legal requirements in respect of factory lighting, reference being made both to the Report of the British Departmental Committee on Lighting in Factories and Workshops, the code drawn up by the Illuminating Engineering Society in the States, and the codes introduced by the States of New Jersey and Pennsylvania.

Mr. Clewell agrees with the views expressed in the British Report that the legislative requirements can easily be met without hardship by modern factories, and are intended merely to bring up to standard the more backward works.

Some charts are reproduced comparing the illumination actually found in typical American factories with the legislative values. In well-equipped factories the illumination provided is shown to be well above that desired for fine manufacturing (3 foot-candles), and far above that for rough manufacturing (1·25 foot-candles). On the other hand backward cases are also collected where values ranging from 0·5 to 1 foot-candle are recorded, and these values, while sufficient to meet the requirements of the British Report from the standpoint of the minimum general illumination for safety and convenience, are insufficient for the carrying on of many of the processes, *e.g.*, in machine shops. These figures are, however, striking in showing the very reasonable requirements of the British Report.

In Table II. are collected the requirements as regards illumination of various codes. Here the fundamental difference between the requirements of the American codes for carrying on work, and the values suggested in the British Report, which refer merely to safety and convenience, should be borne in mind.

TABLE II.

ILLUMINATION REQUIREMENTS IN FOOT-CANDLES IN VARIOUS CODES AND BY DIFFERENT AUTHORITIES.

Class of work.	Clewell's "Factory Lighting," 1913.	G.E.C.'s "Handbook on Lighting," 1913.	Wisconsin "Orders," *Minimum*, 1913.*	Ill. Eng. Soc. (U.S.A.) "Code of Lighting," *Minimum*, 1915.	Report of British Departmental Committee on Lighting in Factories and Workshops, *Minimum*, 1915.†	Pennsylvania Code, 1916.		New Jersey Code, 1916.	
						Min.	Good practice.	Min.	Good practice.
General lighting	—	0·08	—	—	0·25	—	—	—	—
Yards, roadways, &c.	—	—	—	—	0·05	0·05	0·05—0·25	0·05	0·05—0·25
Stairways, etc. ..	0·5	0·5	—	0·25	0·1	0·25	0·25—0·5	0·25	0·25—0·5
Foundries ..	—	3	1·5	1·25	0·4	1·25	1·25—2·5	1·25	1·25—2.5
Rough manufacture	3	2	0·75	1·25	—	1·25	1·25—2·5	1·25	1·25—2·5
Fine manufacture	5	5	1·5	3·5	—	3·5	3·5 —6	3·5	3·5 —6
Extra fine manufacture ..	—	—	—	—	—	5	10—15	5	10—15

* The values in this column have been estimated from the specifications of candlepower per square foot as listed in the original code (now being revised).

† The values given in this Report were intended only to cover the amount of illumination necessary in the interests of safety and convenience. Additional illumination for the purpose of carrying on the work would be required, but these values have not yet been specified.

Dealing with the problem of enforcement Mr. Clewell recognises the difficulties involved in prescribing a standard of illumination on the working area, which would require to be checked with illumination photometers. These, however, can be met in course of time. Other methods of dealing with the amount of light provided, *e.g.*, in terms of watts per square foot or candlepower per square foot (which figures in the Wisconsin shop-lighting orders, issued in 1913 but now undergoing revision) are quite unsatisfactory. For the former takes no account of the different efficiency of illuminants, and even the latter ignores the very important influence of the location of the lights and type of reflector employed.

The mere statement of illumination by itself, however, only covers a part of the problem and requires to be considered in conjunction with recommendations on other important points such as the avoidance of glare.

THEATRE LIGHTS OF THE PAST.

Under this title the *Edison Monthly* prints some interesting notes on the beginnings of stage lighting.

For three centuries, from 1500—1800, the stage was lighted by candles and oil lamps set in rows across the front of the platform, while the most elaborate effect produced was to place a light on the end of a pole, which the audience were expected to recognise as the moon.

Then for eighty years, from 1800—1890 there came a new era with gas as the illuminant. The lighting effects were considered miraculous in comparison with those of the pre-gas days. Yet the difficulties in some of these early displays were quite formidable. The Academy of Music in New York is stated to have been one of the first theatres to use gas. Every night, long before the doors were opened, the three gas men who constituted the regular house staff began their work. First came the huge chandelier, made up of more than a ton of iron and glass and carrying four hundred burners, all of which had to be lighted by hand. Stage lights took up almost as much space as the scenery itself. Long yards of rubber pipe trailed across the wings. By an ingenious system of pulleys a light placed behind a yellow disc simulating the rising sun was made to ascend in the heavens, dragging its gas tube unseen behind it. If the pulleys creaked and the light wobbled it was still a mighty fine moon compared with the light on a stick that it replaced.

Electric lighting is generally believed to have been first introduced at the Lyceum Theatre by Henry Irving, an enthusiast for lighting effects. It was introduced at the Bijou Theatre, Boston, in 1882, where a small Edison plant was installed. From that time onwards the tendency has been towards more and more elaborate effects. Quite recently, however, there has been a revulsion towards more simple lighting. The Irish Players in a piece known as "The Rising of the Moon" struck a new note by simply playing a strong yellow illumination from one side, giving sharp relief effects.

To-day it is recognised that lighting is a most valuable tool, capable of adaptation within wide limits according to the nature of the performance.

In modern theatrical performances the appeal to the eye is quite as important as the spoken words, and during recent years illumination has played an ever-increasing part in performances on the stage.

NEUTRAL GLASSES AND OTHER METHODS OF DIMINISHING INCIDENT LIGHT IN ILLUMINATION PHOTOMETRY.

By an Engineering Correspondent.

There is one problem that everyone interested in the design of photometric instruments has met—the difficulty of bringing about diminution of transmitted light according to a prescribed law.

The problem requires a little explanation. In almost every photometric instrument the adjustment of the photometric balance is made by adjusting the illumination from the small electric lamp within the photometer. This adjustment of illumination may be made in several ways, by altering the distance of the lamp, the angle of inclination of the light on the photometric surface, or the current through the lamp; or by making use of a diffusing screen, the area of which can be masked in varying degree by a suitable shutter. All these methods are used in well-known illumination-photometers.

Only rarely is there any attempt to adjust the photometric balance by altering the intensity of the transmitted light, *i.e.*, the light entering the photometer from the lamp or surface being examined. There are practically only two instances of this, the use of neutral absorbing glasses and the special tube-contrivance employed by Trotter and Waldram in making daylight measurements. In view of the very high illumination to be measured in the case of daylight some such device is obviously necessary. The Trotter-Waldram tube-device utilises a known portion of a presumably evenly bright white sky, but this method, while convenient for certain daylight problems, has obvious limitations.

The most usual device to extend the range of illumination photometers is to use dark glasses of known transmission and presumed neutral qualities to absorb a prescribed percentage of the incident light. For example, such glasses may transmit 10 or 1 per cent. of the light, enabling the scale of the instrument to be multiplied by 10 or 100.

It will be observed that in both cases all that is attempted is to introduce a convenient multiplying constant to extend the scale. It is not sought to diminish the incident light according to a definite law, and to indicate this progressive diminution on a suitable scale.

On the other hand, in early attempts to make photometers of the "extinction" class this was suggested. If we are ever successful in finding some suitable basis for illumination-photometers other than the glow-lamp and battery—if, for example, we were able to obtain a judgment by noting the illumination at which fine detail or colour just fails to be perceived—we should have to rely on diminution of the incident light, as there would be no illumination from within the instrument to adjust.

The most obvious way of producing this diminution is to use a wedge of neutral glass which can be gradually moved across the field of view, giving a progressively increasing absorption of light, as the thickness of the glass increases. The method has the objection that unless the tapering of the wedge is very gradual the two sides of the field will be unequally illuminated; also that it is difficult to obtain wedges uniform in dimensions and absorbing power, free from striations or bubbles, and of true neutral composition.

In any case they are expensive to make—in present circumstances they would be practically unobtainable. A somewhat simpler method, suggested by Mr. J. M. Trezise,* and applicable to small fields, is to allow the light to pass through a plate of neutral glass, which can be tilted to receive the light at various angles. In this way the thickness of glass is progressively increased, and the amount of light lost by reflection from the surface of the glass will also become greater. The illumination could thus be varied considerably, and the alteration indicated on a scale by calibration. The law is empirical, and the scale would only be open over a certain range.

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* *Illum. Eng.*, March 1916.

Neither of these methods would give rise to a straight line law, and at present there is always the doubt whether any absorbing glass is really neutral if used in sufficient thickness to transmit only a relatively small amount of light. According to a recent paper by H. P. Gage*, so-called neutral glass is at present made by the combination of two complimentary absorptions such as yellow and blue, and there are commonly bands in the spectrum. To obtain a perfectly neutral glass with a smooth spectrum would require a considerable amount of research, but it would be a great advantage if the composition of such a glass could be definitely determined. The best neutral glasses at present available answer, with fair accuracy, for white light, but it would probably be injudicious to rely on them too closely in studying coloured light.

It has been suggested that one might substitute for neutral glasses special screens, made up of a fine network of wires, or fine lines ruled on a transparent surface so as to allow a definite percentage of light to pass. It might then be possible to diminish the light by altering the angle of inclination of such screens, or adjusting the relative positions of two lying one upon the other.

There are possibilities in this direction and the method has at least the apparent advantage of eliminating the colour-difficulty. But it is not enough merely to rule opaque lines at equal intervals. This would only give 50 per cent. absorption. In order to get an absorption of 90 or 99 per cent. it would be necessary for the screen either to consist of fine clear lines at intervals with an appropriate black space between them, or clear dots on a black ground.

If the screen were being used close to an evenly bright surface, such as an illuminated opal glass, one could no doubt easily produce the required absorption in this way. But if it is to be used irrespective of the dimensions of the light source or in an illumination photometer of the Lumeter type in which observations are made of a distant object with the absorbing screen relatively close to the eye, the lines would have to be extremely thin, and the dots extremely small, otherwise the effect would not be that of a neutral glass, and the eye would merely observe isolated bright points. Indeed, if one considers a 99 per cent. absorption glass, in which the ratio of dark area to bright area is 99 : 1, it seems rather questionable whether the clear dots would not appear as individual bright specks, even if of microscopical dimensions.

The experimental difficulties are also not inconsiderable. The easiest method to produce such a screen would perhaps be to photograph down from a large diagram, but this introduces the question of the permanence, as regards absorbing power, of the clear portions of the gelatine. A more accurate method would be to scratch lines on glass coated with a thin black surface with a dividing machine; even here, to ensure strict accuracy, allowance would have to be made for the absorption of the clear glass, and the surface of the screen would have to be protected with a cover glass, which would again introduce some absorption and would have to be kept scrupulously clean.

Among other "dimming" devices that have been tried is the method of crossed Nicols. This is employed in some spectrophotometers. But this method is open to the objection that one cannot see the outlines of an observed object clearly through such an arrangement. It would therefore not be convenient for "brightness-photometers," and in any case, unless very large and expensive Nicols were used, the distance of the observed source from the Nicols would probably have to be kept constant during tests in order to avoid possible errors due to variation in the amount of light lost in transmission.

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* *Trans. Illum. Eng. Soc.*, U.S.A., 1916.

A more hopeful plan would perhaps be to produce the polarisation effect by double reflection from two inclined pieces of black glass. The image could then be distinguished, but the transmission would always be a long way below 100%. Polarisation methods, like the neutral glass wedge, do not give a straight line law.

A final possibility is to diminish the incident light by a method similar in principle to the Trotter-Waldram daylight device. The observed white test-plate, used with a brightness photometer of the Lumeter type, might be treated in a similar manner to the white sky. One might, for example, introduce into the photometer a tube, having at one end an opal glass and at the other a variable opening such that the area of the illuminated surface subtended at the opal glass might be altered within given limits. This method has one advantage, that a straight line law of diminution could be obtained. But in practice there are inconveniences. Unless the area of the test plate is very large the diminution in illumination brought about by inserting such an accessory apparatus is very great; it is in fact only useful when the diminution required is of the order of 1/100 or 1/1000. Also, owing to the interposition of the opal glass the observer can no longer see the surface being examined; by inadvertently tilting the instrument slightly so that the observed surface no longer covered the reducing aperture, he might therefore easily make very big errors.

These considerations apparently render the method of small practical utility for observing the brightness of illuminated surfaces, except in very special cases. It has, however, merits when candle-power is to be tested and the source and photometer can be fixed at a convenient distance apart. In these circumstances it is possible to bring about in a very small space an almost indefinitely large reduction in illumination, the value of which can be accurately determined by calibration. A device substantially in accordance with this principle was used at the National Physical Laboratory a few years ago in some experiments on the observation of faint lights.

To sum up, it is evident that there are objections to all the devices hitherto proposed for diminishing the light from the source or surface tested in illumination photometers. Research in this direction is needed, for success in meeting the problem might lead to considerable simplifications in the design of such instruments, and to extensions of their present fields of utility.

THE UTILISATION OF IRISH PEAT.

The Fuel Research Board, with the sanction of the Committee of the Privy Council for Scientific and Industrial Research, has appointed a Committee of Inquiry into the utilisation of Irish peat deposits.

The terms of reference to the Committee are as follows:—

"To enquire into and to consider the experience already gained in Ireland in respect of the winning, preparation and use of peat for fuel and for other purposes, and to suggest what means shall be taken to ascertain the conditions under which, in the most favourably situated localities, it can be profitably won, prepared and used, having regard to the economic conditions in Ireland; and to report to the Fuel Research Board."

The following appointments have been made to the Committee:—Sir John Purser Griffith, M.A.I., M.Inst.C.E. (Chairman), Professor Hugh Ryan, M.A., D.Sc., F.I.C., Professor Sydney Young, D.Sc., F.R.S., Mr. George Fletcher (Dept. of Agriculture and Technical Instruction for Ireland), Professor Pierce Purcell, M.A., M.A.I., Assoc.M.Inst.C.E. (Secretary).

All inquiries should be addressed to: The Secretary, The Peat Enquiry Committee, University College, Dublin.

A STANDARD SPECIFICATION FOR GLOW-LAMPS.*

Prepared by the Swiss Union of Electricity Works.

THE specification last issued by the V.S.E. (1909-10) referred mainly to carbon lamps, and contained relatively few conditions applying to metal filament lamps. The development of the latter, and also the introduction of half-watt lamps, has made a new specification applicable to both types of lamps desirable.

In what follows we give a summary of the new specification. Two points deserve special reference :—

(A) In view of the different types of metal filament lamps introduced, having widely different distribution of light, the old ratio between mean horizontal candlepower and mean spherical candlepower (given as 1·2), often no longer applies. This is particularly true of gas-filled lamps. It has accordingly been decided to state illuminating value in mean spherical candlepower in future. In the present specification both mean spherical and mean horizontal values are given for vacuum lamps.

(B) It is now recognised as more convenient for lamps to be graded and marked in watts. This practice, which has become usual in other countries, is now to be adopted in Switzerland, having been agreed to by the chief lamp-makers. For the present year, however, manufacturers will supply lamps marked in candlepower if specially desired to do so.

In the case of carbon filament lamps, for which, as stated above, no new conditions are specified, three different specific consumptions have hitherto been recognised. For metal filament lamps two types are now suggested, designated "A" and "B," having respectively a useful life of 800 and 1,600 hours (*i.e.*, a period of use of 800 and 1,600 hours before the candlepower has fallen by 20 per cent). In the case of gas-filled lamps, only one type, with a useful life of 800 hours, is covered by the specification.

On pp. 194—196 we give a summary of the specification. In order to avoid repetition, it is convenient to deal separately with clauses that refer respectively to vacuum and gas-filled lamps, which are dealt with on adjacent columns, and to arrange matter which is common to both classes, to go right across the page.

At the conclusion of the specification a definition of mean spherical candlepower is given, and it is suggested that the test should be undertaken by means of the Ulbricht Globe, which is briefly described. It is recommended that the globe should be calibrated by observation of a lamp of known mean spherical candlepower. This enables the constant of the globe to be readily determined, and the mean spherical candlepower of a series of lamps to be thus quickly obtained.

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* Abstract of Specification prepared by the Glühlampen-Einkaufs-Vereinigung of the Verband Schweiz. Elektricitätswerke, published in the *Schweiz. Elektrotechnischer Verein Bulletin*, June, 1917.

SPECIFICATION FOR METAL FILAMENT LAMPS.

Vacuum Lamps.

(1) The conditions apply to all consignments of not less than 100 lamps. They are not applicable to lamps of voltages below 100 or above 250, nor to lamps which fall without the standard range of 10, 15, 20, 25, 30, 40, 50, 60, 80, and 100 watts, nor lamps with obscured or coloured bulbs.

(2) Lamps are supplied in two standard types, of high and low specific consumption corresponding to useful lives of 800 and 1,600 hours respectively, and denoted by the letters A and B.

Gas-Filled Lamps.

(1) The conditions apply to all consignments of not less than 25v. lamps. They are not applicable to lamps of voltages under 100 or exceeding 250, nor to lamps which fall without the standard range of 50, 100, 200, 300, 400, 600, 1,000, 2,000, 3,000, and 5,000 watts, nor to lamps with obscured or coloured bulbs.

(2) Lamps are to be supplied with a useful life of at least 800 hours.

(3) Lamps are to be supplied according to their total consumption in watts.

(4) Lamps shall be marked on their bulbs with the following information :—

(A) Name of the maker ; (B) supply pressure, the word "volt" being omitted ; (C) consumption, the word "watt" indicated ; (D) the letters "G.E.V.," and, *at the desire of the purchaser,* (E) the mean spherical candlepower ; and (F) the name of the purchaser.

Lamps which do not comply, or only partially comply, with these conditions will not be accepted for test, and may be rejected by the purchaser.

Type of vacuum lamp to be indicated by the letter "A" or "B."

(5) Lamps must be without defects as regards construction and material, and must be made of clear glass without blemish and of symmetrical form. The mounting of the lamp in the socket must be strictly axial, and the attachment of the connection wires to the socket executed solidly and with acid-free solution.

Sockets of lamps must comply with the forms prescribed by the "S.E.V."

(6) The testing of lamps for consumption and mean spherical candlepower must be done at the supply voltage indicated on lamp.

(7) Lamps must comply with the following requirements as regards consumption and candlepower :—

The consumption of vacuum lamps, as determined by test, must not deviate above or below the marked value by 4 per cent. For lamps under 25 watts the variation must not exceed ± 1 watt.

The mean spherical candlepower, as determined by test, must not deviate by more than 15 per cent. from the data given in the table on the opposite page.

The consumption of gas-filled lamps, as determined by test, must not deviate above or below the marked value by more than 5 per cent.

The value of the mean spherical candlepower, as determined by test, must not deviate by more than ± 15 per cent. from the marked value, whereby the specific consumption in watts per candle (mean spherical Hefner) must not be higher than the values indicated in the table on the opposite page.

CANDLEPOWER OF VACUUM LAMPS.

Consumption. Watts.	Marked Voltage.	Mean sph. C.P. Hefner.*	
		Type A.	Type B.
10	100–139	7·5	5·0
	140–199	7·0	
	200–250	6·5	
15	100–130	12·0	9·0
	140–199	11.5	
	200–250	11·0	
20	100–139	16·5	13·5
	140–199	16·0	12·0
	200–250	15·5	10·0
25	100–139	21·0	17·5
	140–199	20·5	16·5
	200–250	20·0	15·0
30	100–139	25·5	21·5
	140–199	25·0	20·5
	200–250	24·5	19·0
40	100–139	34·5	29·0
	140–199	34·0	28·0
	200–250	33·0	27·0
50	100–139	42·0	36·0
	140–199	42·0	35·0
	200–250	42·0	34·5
60	100–139	51·0	44·0
	140–199	51·0	43·5
	200–250	51·0	43·0
80	100–139	67·0	59·0
	140–199	67·0	58·5
	200–250	67·0	58·0
100	100–139	85·0	76·0
	140–199	85·0	75·0
	200–250	85·0	74·0

GAS-FILLED LAMPS.

Consumption. Watts.	Maximum specific consumption in Watts per Hefner* for 8 voltages of :—	
	100–174 volts.	175–250 volts.
50	1·0	—
100	0·9	1·0
200	0·8	0·9
300	0·7	0·8
400	0·65	0·7
600	—	—
1000 (and over)	0·65	0·65

* [N.B.—*To convert values of candlepower expressed in Hefners into "international" candles, the above results must be multiplied by the factor* 0·9.—ED.]

(8) By the "useful life" is understood the period of continuous burning at the indicated voltage, during which the mean spherical candlepower of the lamps does not diminish by more than 20 per cent. from its initial value; if the lamps fail before this point is attained, the period of burning up to this point is regarded as the useful life.

For life-tests only those lamps which comply with the conditions set forth in (7) should be accepted, and from these the tests should be carried out on those lamps whose consumption and candlepower, at the indicated voltage, approach as close as possible to the prescribed values.

The life-test should be undertaken in the case of vacuum lamps of the type A, on the indicated voltage; in the case of lamps of type B at a higher voltage such that the specific consumption in watts per candle of the group of five lamps of the same kind to be tested (in accordance with (9)) is reduced to that of A lamps of corresponding power.

The life-test on gas-filled lamps should be undertaken at the indicated voltage.

(9) The test of useful life, undertaken on behalf of the purchaser, is to be made on a selection of 5 out of each batch of lamps of the same kind. Lamps which are broken in the process of unpacking and testing are not to be included in results.

The tests of candlepower and consumption are to be made on 10 per cent. of the lamps in each batch submitted. If the number of lamps is less than 150, at least 15 lamps should be tested ; if over 15,000 lamps, at the most 1,500 should be tested. If lamps of different types and sizes are included, tests should be made on 10 per cent. of each type or size ; in the case of batches from 150 to 15,000, they should be selected proportionately out of the 15 and 15,000 respectively set aside for test.

Tests of candlepower and consumption should be made on 5 per cent., but on at least 10 lamps of each power.

(10) A consignment of lamps can be returned :—

(A) If the useful life of more than 40 per cent. of the lamps tested has not reached 800 hours.

(B) Within 30 days after the delivery of the lamps at the testing laboratory of the S.E.V., if more than 20 per cent. of the lamps tested do not comply with one or more of the prescribed conditions in regard to construction, candlepower, or consumption.

If lamps are returned as a result of failure to pass tests of useful life the cost of such life-tests on selected lamps is to be met by the seller of the lamps. In the event of the purchaser having put into use a portion of the consignment, the above condition shall apply to the remainder of the consignment which has not yet been put into use. Lamps which have been subjected to test may be returned, but those that have been put into use cannot.

(11) The place of test prescribed is the Laboratory (Materialprüfanstalt) of the Schweizerischer Elektrotechnischer Verein at Zurich. Lamps for test should be forwarded to this address immediately after the receipt of a consignment by the purchaser.

(12) The Laboratory of the S.E.V. keeps records of the tests to which appeal may be made in case of dispute, and which are accepted both by the seller and purchaser.

The contesting of consignments rests with the purchaser.

RADIATION FROM HELICAL FILAMENTS.

A recent investigation undertaken at the Bureau of Standards by W. Coblentz, deals with the phenomenon that the interior of the helices of filaments in half-watt lamps appears to be considerably brighter than the exterior portions—in some cases nearly twice as bright.

It has been shown that this cannot be due to higher temperature. Pyrometric and other measurements make it clear that the difference in temperature cannot exceed 5 deg., whereas a difference of 200 deg. would be necessary to explain the greater brightness.

Further investigations showed that the light from within the helix is different in quality from that emitted by its outer surfaces. It is highly polarised and also distinctly bluer in tint.

The probable explanation lies in multiple reflection from the adjacent tungsten surfaces. This would have the effect of increasing the brightness and, as polished tungsten may be expected to exercise selective reflection, may also explain the difference in colour.

INSPECTION LAMP FOR MOTORISTS.

In *Popular Mechanics* a useful form of inspection lamp for motorists and others is described. It consists of a small lamp in metal case, fed by flexible leads from a portable battery, and attached by an 18 in. length of flexible tube to a handle. This is very serviceable for the inspection of mechanism which is difficult of access. An additional feature is the use of a magnetised metal case surrounding the lamp which is very convenient for picking up small iron parts.

SHORT NOTES
ON
ILLUMINATING ENGINEERING.

ILLUMINATING ENGINEERING SOCIETY (U.S.A.)

National Committee on Lighting in the United States.

The Illuminating Engineering Society (U.S.A.) has been given opportunity to co-operate with the Council of National Defence by the appointment of the National Committee on Lighting. This committee was appointed by Mr. Samuel Gompers, Chairman of the Committee on Labour of the Advisory Commission of the Council of National Defence.

The National Committee on Lighting will serve as a Sub-Committee to advise on all matters relating to this subject that come within the scope of the Committee on Labour, including the conservation of health and welfare of workers. This work will deal primarily with the lighting of all factories, mills, industrial establishments and other work places, especially munition plants, government shops, arsenals, and all concerns directly under contract with the Government.

The work of the Committee on Lighting will be directed broadly to the problem of improving lighting conditions with the following objects in mind :—

(*a*) Conservation of the eyesight of workmen.
(*b*) Minimising, accidents.
(*c*) Increasing production.
(*d*) Decreasing spoilage.
(*e*) Protection of property and persons

To assist in accomplishing these ends, the Committee will prepare a specification containing rules for adequate and safe lighting, including data for the minimum and desirable standards of light intensity for different classes of work, and directions for minimising glare. It is planned to supplement these rules by descriptive notes and illustrations that will set forth plainly and definitely the way in which the recommendations of the Committee may be carried out in practice. The National Committee on Lighting has been officially authorised to proceed with this work.

Arrangements for Convention.

In view of the cancelling of the usual Annual Convention, owing to the war, the Society will hold a "Corresponding Convention, the papers being circulated amongst members and written contributions to the discussion invited.

Titles and authors of papers will be published in advance in the *Transactions*, and any who are interested can obtain copies upon application to the General Offices of the Society, 29, West 39th Street, New York, U.S.A.

An Illumination Index.

The Committee on Progress is arranging to compile, at regular intervals, an index of important articles dealing with illumination, arranged in chronological order.

In future this index will appear in each issue of the *Transactions*.

Lecture on Shop-Lighting.

A popular lecture on "Store-Lighting," prepared by the Committee on Popular Lectures, is now ready for distribution. It is expected that a similar lecture on "Home-Lighting" will be available shortly.

School Lighting.

Mr. L. B. Marks, the Chairman of the Committee on Lighting Legislation, reports that progress has been made with the preparation of a "Code on School Lighting," which will eventually be made available to the general public.

A JAPANESE ILLUMINATING ENGINEERING SOCIETY.

Readers will be interested to learn that an Illuminating Engineering Society has recently been formed in Japan.

We hope shortly to give fuller particulars of this new offshoot of the illuminating engineering movement. Meantime we wish it every success.

WHITEWASH AS AN AID TO CLEANLINESS.

In *Popular Mechanics* an interesting illustration of the value of light as an aid to cleanliness is mentioned. In a certain Boston factory workers had acquired the insanitary habit of spitting in corners. By the simple expedient of painting the corners with whitewash the habit was checked. The whitewash acted as a reminder and presumably its clean surface, on which stains were readily visible, had a useful suggestive influence.

The janitor, whose duty it was to attend to the sweeping out of corners, was also beneficially affected and, after the whitewash had been applied, carried out his duties with greater care than hitherto. It would probably often be found that in store-rooms, where rubbish tends to accumulate, the simple expedient of whitewashing, by improving the illumination, would promote tidiness.

ILLUMINATION IN WAR TIME—IN THIS COUNTRY AND IN THE UNITED STATES.

In a recent issue of *Electricity* a curious difference in the practice in regard to street lighting in war time in this country and in the United States is noted.

The general tendency here is to reduce illumination to a minimum, whereas in America we hear of *extra* war-lighting,—important yards, bridges, &c., being strongly illuminated. The explanation is interesting. In this country the chief consideration is precaution against hostile aircraft, while under the vigilant action of the police any danger from alien enemies normally resident in the chief cities has been practically suppressed.

In the United States, on the other hand, the danger from air-raids does not exist, but in view of the very large mixed population the possibility of damage by enemy aliens requires consideration. Accordingly, the intention is to flood all important areas with light so as to render the task of any lurking malefactor as difficult as possible.

As our contemporary remarks, it may be impracticable for us to adopt this safety precaution in England, but the lesson is one that will well repay consideration when we return to normal conditions.

LIABILITY FOR STREET ACCIDENTS DUE TO INSUFFICIENT LIGHTING.

The *Gas World* (July 14th, 1917) records a case in the Court of Appeal on July 5th of considerable interest to illuminating engineers.

On a night in April, 1916, Mr. Thos. Morrison, of Leeds, was crossing the street, and on reaching the far side of the road he came into contact with one of the iron spikes fencing a tree, with the result that the sight of one of his eyes was practically destroyed. He therefore sued the Corporation of Sheffield for personal injuries sustained through the decreased street lighting, and at the Leeds Assizes was awarded £660 10s. damages, the Jury finding that the guard was dangerous in the circumstances of the darkness that existed, and that the Corporation ought to have taken reasonable measures to have neutralised the danger. The Corporation now appealed against this decision, relying upon the Defence of the Realm Act, and their right to plant trees in the streets under the Public Health Amendment Act of 1890.

The Court dismissed the appeal. The Lord Justice said that there was an obligation on the defendants to use reasonable care for the whole time during which they maintained the guard to the trees, and they were not entitled to allow them to become dangerous to those who used the highway.

SUBMARINE CRAFT WITHOUT PERISCOPES.

According to an article in the *Revista Marittima*, quoted in the journal of the Royal Society of Arts for July 12th, U boats have now been constructed without periscopes. The arrangement substituted, which appears to be in the experimental stage, consists of two lenses, one on either side of the vessel, which are used in conjunction with other lenses and mirrors. If necessary these lenses and mirrors can also be utilised to project a beam of light outwards from the vessel. The drawback to the device is that the vessel has to be navigated nearer the surface, but it is thought that this is outweighed by the advantage that the arrangement is less visible from a distance.

INVISIBLE SUBMARINES.

It is well known that submarines when below the water can often be located by inspection from a height above. Aeroplanes, for example, are used to locate submarines in this way.

A recent article by H. Woodhouse in *Flying*, summarised in the Franklin Institute for June, mentions that exhaustive experiments have been made with a view to painting submarines in such colours as to render them indistinguishable from the water in which they lie. A limitation to this method is imposed by the fact that submarines have often to traverse large distances, and it is therefore difficult to [devise a coloration which will blend with the varied conditions in which they are moving; small boats for coasting purposes, which always operate in similar conditions, are more easily treated in this way.

Another point of some importance is the painting of friendly submarines so as to be clearly distinguishable from hostile ones. If distinctive marks are adopted there is always the danger of their being copied by the enemy, and it is possible that some enemy boats may escape owing to uncertainty as to identity.

LIGHTING AT THE PANAMA-PACIFIC EXHIBITION.

The *Proceedings* of the American Institute of Electrical Engineers for June contains a very complete and interesting account of the special lighting of the above exhibition, by W. D'a Ryan. In addition to detailed diagrams and sketches showing the types of fixtures and their location to meet various lighting problems, the contribution is assisted by a most effective series of colour-prints showing the actual appearance of sections of the exhibition by night. Considerable pains were evidently taken to blend the colours of the courts and exteriors of buildings with the hues of illuminants, and the effective use of concealed lighting produced some wonderful effects.

BRITISH SCIENCE GUILD.

ELEVENTH ANNUAL REPORT OF THE EXECUTIVE COMMITTEE (JUNE, 1917).

In our April issue we gave an account of the proceedings at the last Annual Meeting of the Guild, when addresses were delivered by the Rt. Hon. H. A. L. Fisher, Lord Sydenham, and Mr. H. G. Wells.

In the bulletin now issued a complete account of the annual meeting is given, and the Annual Report gives a valuable summary of recent progress in the promotion of scientific and industrial research. The Appendices, which include a contribution by Professor Barker on the Metric System and the Textile Industries, and notes on Endowment of Education and Research and National Instruction in Technical Optics, are also of considerable interest.

PRODUCTION OF GAS IN THE UNITED STATES.

It is common knowledge that the output of gas in this country has increased enormously since the outbreak of war, and some striking figures on this point were presented in the lecture by Mr. H. M. Thornton before the Royal Society of Arts on April 18th.*

We notice that in a Report of the U.S. Geological Survey Mr- C. E. Lesher gives some useful information relating to the development of gas production in the United States.†

From 1908 to 1915 the output of coal-gas for all purposes has increased from about 150 thousand million cubic feet to about 180 thousand million. The consumption *per capita* of population has risen from 1,417 to 1,809 cub. ft. in the same period. In many respects the year 1908 seems to have been a turning-point in the history of the American gas industry. Equally striking has been the progressive reduction in price simultaneous with the increase in production.

The very marked increase since 1908 seems to be due largely to the greater utilisation of gas for fuel. Another interesting point is the development of oil and other special varieties of gas, bringing the total consumption up to about 270 thousand million cub. ft.

CAMPAIGN TO SECURE MORE GAS LIGHTING BUSINESS.

The National Commercial Gas Association in Canada is showing great activity in regard to lighting. The Illumination Committee has recently addressed to a large number of cities a series of inquiries on the subject, the following queries being included :—

"Will you procure and send to this office the following :—

"Photographs of gas lighting installations (residential, commercial, and factory).

"Number of and types of lamps in each installation.

"Total hourly consumption of lamps in each installation.

"Do you conduct special lighting campaigns ?

"Are you endeavouring to hold your present and secure new gas lighting ?

"What kind of gas lighting literature can you use for general distribution ?

"Are your display windows and show-rooms lighted at night ? Kindly send us photographs of each."

An inquiry is also being instituted on the best methods of getting in touch with architects in all the leading cities.

GAS-RIPENED BANANAS.

The *Co-partnership Journal* for May contains a number of interesting notes, including an account of some experiments to ripen bananas by the heat from gas at Idaho, in the Rocky Mountains.

The bananas are hung from rafters in air-tight rooms, each about thirty feet square and six feet high. Gas hot-plates are placed on the floor and heat wash-tubs filled with water, the vapour from which maintains the air of the room at 65—70° Fahr.

The bananas speedily ripen in these circumstances, and the treatment should promote the storage of this useful food.

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* *Illum. Eng.*, April, 1917, p. 126.

† *Gas Age*, April, 16th, 1917.

TOPICAL AND INDUSTRIAL SECTION.

[At the request of many of our readers we have extended the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]

SHOP-WINDOW LIGHTING BY CONCEALED LIGHTS.

Even before the war the wastefulness of lighting shop windows by a series of flame arc lamps or other high-power illuminants placed slightly above the eye-level of people in the streets was well recognised by experts in illumination. In the present circumstances such methods are particularly undesirable, as they are responsible indirectly for waste of coal, besides being a great eye-sore in the present darkened condition of the streets.

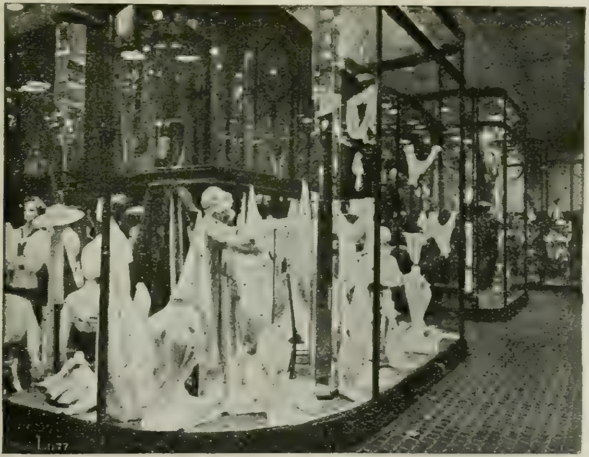

FIG. 1.—Showing concealed lighting of window with half-watt lamps and X-ray reflectors.

Shopkeepers have therefore every inducement to practise the concealed method of lighting, throwing the rays of light on the goods, and emitting little or no light on the roadway.

In ordinary circumstances a window may sometimes be lighted by weather-proof lanterns containing half-watt lamps, the reflectors being so shaped as to reflect the light into the window but shield it from the eyes of passers-by. The method may be used in flat windows and in cases where there are no successive lines of goods such as would cast inconvenient shadows. But it is comparatively seldom that this method can be employed.

In the accompanying illustration, for which we are indebted to the British Thomson Houston Co., Ltd., the lighting is carried out with Mazda "half-watt" lamps and X-ray reflectors placed inside the window but well above the line of vision. In these circumstances we get the effect of light on the goods, without the filaments being visible to people outside the shop.

REVIEW OF BOOK.

Health of Munition Workers' Committee, Memorandum No. 18 *: "Further satistical information concerning output in relation to Hours of Work, with special reference to the influence of Sunday Labour." By H. M. Vernon, M.D.*

This bulletin is supplementary to Memorandum No. 5 on "Hours of Work." Dr. Vernon's further researches confirm conclusively the views tentatively suggested regarding the prejudicial effect of excessive hours and Sunday labour. Groups of workers have been kept under observation for long periods and their daily and weekly variations in output analysed. In the case of 100 women kept under observation for more than a year, it is shown clearly that a reduction in hours of work and the enforcement of a rest on Sunday has, so far from diminishing output, actually increased it, and a similar result is recorded for 56 men engaged in heavy labour.

The whole question is studied in a most thorough and scientific way. The cumulative influence of fatigue during the week can be clearly traced by diagrams, and the benefit of the pause for recuperation on Sunday is manifest.

One incidental point of great interest is the study of possible limitation of output. By an ingenious method based on the laws of probability, Dr. Vernon is able to confirm his contention that there were no trade union restrictions on the output of workers. The method applied may suggest a useful test in other cases.

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PERSONAL.

Mr. A. P. Trotter, after 21 years Government service, is returning to professional practice as a Consulting Engineer and is joining Messrs. Handcock and Dykes, as partner in the firm of Handcock, Dykes and Trotter, at 11, Victoria Street, London, S.W.1.

Mr. Trotter is B.A. of Cambridge, Member of the Institution of Civil Engineers, Member of the Institution of Mechanical Engineers, Member of Council of the Institution of Electrical Engineers, President of the Illuminating Engineering Society, Vice-Chairman of the National Illumination Commission of Great Britain (affiliated to the International Illumination Commission), Chairman of the Joint Committee on Illuminating Engineering of the Department of Scientific and Industrial Research, and member of other scientific institutions.

In 1896 he took up the post of Electrical Engineer to the Government of the Cape of Good Hope, and in 1899 he returned to London, since when he has been electrical adviser to the Board of Trade

Readers of this journal will join us in wishing Mr. Trotter every success in his new work.

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SIMPLEX ANTI-ZEPPELIN REFLECTORS.

Some recent lists issued by Messrs. Simplex Conduits, Ltd., show a variety of metal reflectors that are stated to be particularly well adapted to conditions of industrial lighting at the present time. Of special interest are the "Anti-Zeppelin" reflectors, an example of which is shown in Fig. 1. This variety is intended for half-watt lamps, and is of the "intensive" type; a corresponding "extensive" type, intended to give a wider distribution of light, is also made.

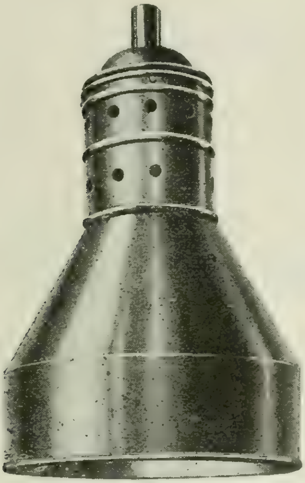

FIG. 1.—Simplex "Anti-Zeppelin" Reflector. (Intensive type for half-watt lamps.)

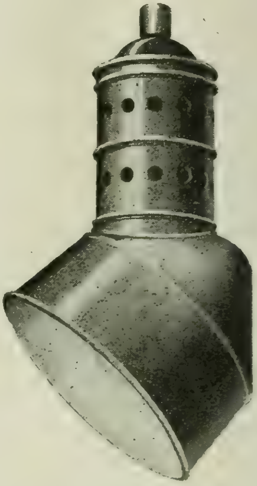

FIG. 2.—Simplex Angle Reflector for half-watt lamps.

These reflectors are particularly suitable for lighting factories with much window space or roof-lighting. The Lighting Regulations forbid the exhibition of unscreened lights in such cases. With this type of reflector the lamp is completely hidden, and they have also the advantage from an illuminating engineering standpoint of avoiding glare and directing the light where it is chiefly wanted—on the work being executed.

It would be useful also to have the polar curves of light-distribution of these units, and we would suggest that these should be shown in the next edition of these lists.

The other illustration shows an Angle Reflector, also for half-watt lamps and intended for the illumination of special local positions, or where the interference of girders or belting makes the use of ordinary reflectors impracticable.

EDISWAN PICTURE-LIGHTING-FITTING.

A form of picture lighting fitting has been introduced by the Edison and Swan United Electric Light Co., Ltd., which is claimed to have special advantages for lighting flat surfaces, and for desks, pulpits, and orchestra lighting. We understand that the fitting was employed for lighting the Choir Stalls in Westminster Abbey.

COAL GAS FOR MOTOR TRACTION.

A report issued by the Executive Committee of the British Commercial Gas Association contains much interesting information on the utilisation of compressed coal gas for motor traction, which is stored in cylinders at a pressure ot 20—25 atmospheres. Trial runs have given promising results, and in view of the present shortage of petrol the method has considerable possibilities.

The
ILLUMINATING
ENGINEER
·ELECTRICITY· ·ACETYLENE· ·OIL· ·GAS·
Edited by
LEON GASTER

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EDITORIAL.

Industrial Reconstruction and the Technical Press.

A very useful discussion on the above subject took place before the Circle of Scientific, Technical, and Trade Journalists on September 11th, when Mr. E. J. P. Benn brought before the members a number of important proposals for the better organisation of the industries of the country. Mr. Benn has devoted a great deal of attention to these problems and has been associated with an influential movement in regard to British trade since the outbreak of war. His recent book on "The Trade of To-Morrow" excited keen interest, and it is recognised by thoughtful men that there must necessarily be vast changes in our methods of conducting trade and industry if this country is to keep its proper place in the commercial fabric of the future.

The moment is not quite ripe for the discussion of this subject in great detail, but a considerable amount of preparatory work has been done by Mr. Benn and others and we understand that these problems will fall largely within the scope of the Ministry of Reconstruction. There can be no question that the ground for future advances must be prepared now. It is necessary to feel our way towards the new measures that will have to be taken after the war, and while, in the present dislocated state of industry, we can hardly expect immediate vast changes in capacity for production, we can at least institute enquiries, accumulate information, and prepare public opinion.

Attention has been constantly directed to the question of promoting better relations between capital and labour, and the Whitley Report, containing suggestions for the setting up of joint Industrial Councils strongly emphasised the necessity for better facilities for the discussion of labour difficulties and the prevention of industrial strife. The co-operation of employers and employees must be enlisted in the interest of their trade or industry. Their joint efforts must be devoted not only to the settlement of their individual differences, but to the application of scientific and industrial research, the promotion of welfare work and improved education, and the technical problems of manufacture, distribution, and publicity; in regard to the latter, especially, the trade and technical Press can play a most important part.

The Councils suggested under a scheme of Industrial Reconstructtion should therefore have a wide scope. Each industry should be mobilised for common action through its own representatives, and it is further proposed that above all there should be a separate Government Department for encouraging trade, assisted by an Advisory Council. Whatever the method of organisation adopted it is recognised that its main aim must be to remove the conflict of interests between various members of an industry and to enable them to unite their efforts for the common good. We find a general appreciation of the fact that in this country there has been too much individual effort and too little co-operative action.

The problem is a vast one, and there is one section of the community, the trade and technical journalists of the country, who could do a great deal to forward its solution. Editors of scientific, technical and trade journals are in close touch with the industries they represent. They often have access to information such as no individual manufacturer could present, and their journals constitute a medium for the communication of information and ideas to the industries of the country which could hardly be surpassed. There are two direct ways in which their services would be of immediate value, in the compilation of statistics and information, and in preparing the way for industrial reconstruction by discussing schemes and proposals in their columns. This preliminary ventilation of problems is essential. A vast scheme of this kind can only be made successful when the willing co-operation of the trades concerned has been obtained.

We feel confident that the scientific and technical Press will gladly co-operate with the authorities in paving the way for industrial advances, and in the Circle of Scientific, Technical, and Trade Journalists there is available the nucleus of a body through which this section of the Press could be conveniently approached.

Scientific and Industrial Research during 1916—1917.

In referring to the recently issued Report by Mr. A. P. M. Fleming on "Industrial Research in the United States of America" we expressed the hope that the Department of Scientific and Industrial Research would see their way to issuing supplementary publications descriptive of the work being done in this country.

The Report of the Committee of the Privy Council for Scientific and Industrial Research for the year 1916-17 is very timely in this respect, for it shows that its field of work is rapidly widening, and that manufacturers are becoming alive to the value of research and the advantages of co-operative work. A foreword to the Report by Lord Curzon briefly summarises the steps leading to the establishment of the Department, involving the devotion of a sum of £1,000,000 to be expended in research during the period of five years. This step was necessary to provide for continuity of work over this initial period. Reference is made to various channels through which this amount may be expended. The important announcement is made that negotiations have been concluded with the Royal Society for the transfer of the property of the National Physical Laboratory, together with the responsibility for its maintenance and development, to the Department. We sincerely hope that this change will have the effect of relieving the Laboratory from the embarrassments which have hitherto curtailed is useful work, and will enable it to fulfill more completely its objects of existence.

The Report of the Advisory Council is divided into two sections, Part I. describing general measures taken for the encouragement of research, and Part II. summarising the progress made in a number of specific investigations. A broad distinction is drawn between three varieties of research, those which can be profitably undertaken by a single individual or firm; those involving co-operation between a number of firms representing an industry, for the benefit of which, as a whole, the research is undertaken; and researches of such wide national value that they cannot properly be entrusted to a combination of manufacturing firms, but require State supervision on behalf of the nation. As examples of the latter form of research are mentioned the investigations of the Fuel Research Board, the British Fire Prevention Committee, and the Concrete Institute—and the scientific principles underlying illuminating engineering and cold storage are mentioned as other instances of problems which call for national action.

The field covered by various researches is extremely wide. Readers are referred to the abstract on pp. 209-210 for a more detailed account of these investigations. The formation of the Joint Committee on Illuminating Engineering which has already been announced in these columns, is duly recorded, while the references to work on Glass and Optics are specially interesting in view of the establishment of the Research Institute for Glass at Sheffield University, and the Institute of Technical Optics, with a proposed new department for research at the Imperial College. We are very glad to see that the Department have again followed the enterprising procedure adopted in connection with Mr. Fleming's treatise on Industrial Research in the United States, *i.e.*, by issuing with the Report an official abstract summarising its chief conclusions and some of the most important developments in research work during the last year. We feel sure that this practice, which we hope will become general among Government Departments, will be of great assistance to the technical Press in dealing with literature of this kind.

Illuminating Engineering and the Conjoint Board of Scientific Societies.

A Report issued by the Conjoint Board of Scientific Societies, noticed in our last number, referred to the steps being taken to develop National Instruction in Technical Optics. An Advisory and Administrative Committee, under the ægis of the Imperial College of Science and Technology, has been appointed and Mr. F. J. Cheshire has been created Director of Studies in Technical Optics. The need for better facilities for instruction in this branch of knowledge has long been recognised by the most enterprising sections of the optical industry, and we notice that the matter has also been receiving attention in France.

Optics is a subject that touches a very wide circle of industries and professions. Apart from its direct interest to manufacturing opticians and photographic experts it enters into the construction of a great variety of scientific instruments, and comes within the field of the medical man, the radiographic expert, the chemist and physicist, and many others. To illuminating engineers it has a direct interest in two obvious directions, the manufacture of photometric appliances and illuminating glassware. It is, however, scarcely possible to consider fully any appliance for the direction and distribution of light without the principles of optics coming in. A specially good instance of such applications is the manufacture of searchlights and projectors of all kinds, and the consideration of their most efficient use for the many purposes such appliances fulfil.

We therefore hope that in the educational scheme now being evolved the study of illuminating engineering problems will receive due consideration. No doubt the correlation of work carried on at the Imperial College with that undertaken at such institutions as the Northampton Institute and the newly established department of technical optics at the Sheffield University will be studied, and in all these cases there should be provision for the treatment of problems involved in the measurement and distribution of light.

The relation of such studies to the manufacture and use of illuminating glassware is particularly important. This matter has been receiving the consideration of the Illuminating Engineering Society of late, and there is ample evidence of the need for more scientific investigation of such glassware and the provision ot facilities for testing not only the mechanical and general chemical and physical properties of glass for this purpose but also its efficiency from an illuminating engineering standpoint.

Illuminating engineering is now generally recognised as a subject of national importance, and the need of research in this field has been illustrated by the appointment of the Committee on Illuminating Engineering under the Department of Scientific and Industrial Research. We hope that this subject will receive due consideration in the programme of the Conjoint Board. We feel sure that the Illuminating Engineering Society would gladly co-operate in any measures that are taken for the advancement of the study of illumination or the solution of problems involving the practical application of light.

LEON GASTER.

REPORT OF THE COMMITTEE OF THE PRIVY COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH (1916—1917.)*

THIS is the Second Annual Report issued by the new Research Department, which, under all the disadvantages of the strain of war and the shortage of workers, is trying to provide a permanent basis for research in this country and to co-operate with similar attempts in the Dominions.

The Report indicates that there are three ways of organising industrial research. The simplest is the case where a single firm can work out a problem and itself fully exploit the results. In most cases, however, problems of industrial research will concern many firms—sometimes many industries: they will require the expenditure of large sums of money and the co-operation of many workers for long periods of time. But if successful the results will be of immense value.

Most individual firms cannot undertake this long and costly process. Yet why should the State pay the whole cost of winning new knowledge which will be valuable to business men? It is to be hoped that the way out of this dilemma will be found by the establishment of "trade research associations" to be constituted as needed for each industry or group of industries on which are to be represented when possible capital, management, science and labour, and which are to be aided out of the Million Grant to be administered by the Department for the express purpose of establishing such research associations. One association is just about to be constituted for the cotton industry, others are being brought into existence for the wool, flax, shale oil and photographic industries.

There are also many cases where the problem is so complex or else so immediately concerns the consumer rather than the producer that co-operation between manufacturing firms is not possible. This is obviously the case with fuel. Hence the establishment of the Fuel Research Board, which under the direction of a distinguished man of science, Sir George Beilby, will itself conduct research. So, too, with the problems of fire-resisting materials and the determination of standards and constants. Among other such examples are mentioned the scientific problems underlying illuminating engineering and cold storage. All this is direct work for the whole community acting through its special organ of research. It is interesting in this connection that the Royal Society has negotiated with the Department the handing over of the financial responsibility for the conduct of the National Physical Laboratory, where investigations of national importance are constantly going on.

The main lines of policy of the new Department are being slowly worked out. But it is also not neglecting immediately pressing problems. In glass, for instance, a great deal has been already done. Three completely new kinds of optical glass have been discovered by Professor Jackson. A research on light alloys (aluminium, zinc and copper) will be of the utmost importance for the future of aeronautics. A new hard porcelain from purely British materials has already been produced. Researches into the recovery of tin are expected to save the Cornish tin industry £30,000 a year. A large number of other researches are being aided or carried on by the Department. Among these are mentioned domestic heating, atmospheric pollution and conditions in deep and hot mines, and mine-rescue apparatus. A great deal of work is also being done on concrete. Experiments are being conducted on hardness tests of journals and pins, flow of steam through nozzles, heating of buried cables, insulating oil, and the heat-treatment of high speed steel.

In connection with glass and technical optics two important steps have been taken. A Research Institute for Glass has been established at the University of Sheffield. Progress has already been made with several systematic investigations, such as the influence of small amounts of chlorides and sulphates in producing opalescence. These experiments will not overlap other enquiries and co-ordination in this respect has been greatly aided by the formation of the Society of Glass Technology.

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* To be purchased through any bookseller, or directly from H.M. Stationery Office, Imperial House, Kingsway. Price 3d. (by post 4d.).

The other important step in this direction is the step taken towards the foundation of an Institute of Technical Optics. This scheme involves the strengthening of the existing department of technical optics at the Northampton Institute, and the organisation of a special research department at the Imperial College of Science. A single specially constituted Committee is to survey the work of both institutions, the first director being Mr. F. J. Cheshire, lately associated with the department of optical munitions and glassware at the Ministry of Munitions of War. Revised versions in English of several standard works on Optics have also been authorised, and these will be issued at cost price.

A survey is also being made of the whole field for research and additions are being made to the committees dealing with specific subjects. Among such may be mentioned the appointment of a Joint Committee of the Illuminating Engineering Society and the Standing Committees on Engineering and on Glass and Optical Instruments. This Committee has been asked to make a survey of the whole field of research in illuminating engineering.

The Universities will take their place in the new social tissue whose pattern is now being woven. At a considerable number researches, aided or initiated by the Department, are now going on. At the Universities, too, the future research workers receive their training; and thirty-six (who would otherwise have drifted into immediately remunerative work) were aided by grants from the Department during 1916-17.

The Department has also given considerable thought to the question of encouraging inventors, whose interests will be protected, and who will receive assistance while their inventions are in the developing stage.

The Report ends by noting the altered attitude of manufacturers and men of business towards the claims of research and education, and reiterates the conviction that a sure advance in industrial science can only be made when the field of work is adequately surveyed beforehand and an organised plan of attack carried out.

ILLUMINATING ENGINEERING SOCIETY (U.S.A.).

CORRESPONDENCE CONVENTION.

It will be recalled that owing to the war the usual Convention of the Illuminating Engineering Society in the United States will not take place, but arrangements have been made to circulate the papers submitted with a view to discussion by correspondence.

We understand that the first items on the programme are as follows:—

Presidential Address: W. J. Serrill.

Report of Committee on Nomenclature and Standards: A. E. Kennelly (*Chairman*), C. H. Sharp (*Secretary*).

Illuminating Engineering Publicity: G. H. Stickney.

Economics of Large Building Lighting: C. L. Law and J. E. Buckley.

Illumination Intensities in Large New York Department Stores: W. F. Little and J. F. Dick.

THE ENGINEERING COUNCIL IN THE UNITED STATES.

An important step in the United States has been the formation of the Engineering Council, representative of the leading engineering bodies, to assist the Government in war work. The Council has appointed a War Inventions Committee, which will co-operate with the Naval Advisory Board and other departments at Washington in the solution of war problems. Another Committee has been formed to collect information regarding engineers in the country, and to assist the Council to co-operate with the Authorities by meeting the need for the services of engineers in connection with the war.

PRACTICAL LIMITATIONS IN THE PROJECTION OF LIGHT.*

By J. A. ORANGE, Research Laboratory, General Electric Company.

Preface.

The art of lighting is divided into two sections, ordinary lighting and optical lighting. Most problems connected with the lighting of rooms and streets fall in the one section while all such things as searchlights, magic lanterns and moving picture machines belong to the other. Projection is a convenient term which is used to denote the latter division.

The distinguishing feature of ordinary lighting problems is that the lamps used can fairly be treated as point-sources (except in the matter of glare). Projection questions, on the other hand, will not admit of this kind of treatment, at least if quantitative results are required.

Introduction.

The only sources of light which can be treated as point-sources are the stars. It is true that the action of any source may be deduced by considering it as a group of infinitesimal elements and accounting for each one in turn. There is, however, another method which is far less involved.

Brightness.

We must first understand what is meant technically by brightness. The term is used of surfaces—not necessarily surfaces of imposing extent, for the finest wire is considered at times—and it is a matter of appearance as determined by the conditions of the moment. Thus white paper in a dark room has zero brightness, in average daylight the brightness would be of the order of $\frac{1}{6}$ of a unit, and in strong sunlight 15 units. Brightness may be due to self-luminosity, as in the case of red-hot iron or phosphorescent paint in a dark room, or it may arise indirectly as in the case of all ordinary objects in a lighted room.

Thus the illumination values at various points due to a red-hot poker follow the same rule as do those due to a painted model of the poker illuminated in an appropriate fashion. Similarly, the illuminating effect of a d-c. carbon arc might be reproduced by a model having a crater represented in white paint. In both cases the sole difference would be one of the scale of values and would be explained entirely by the differing degrees of brightness.

Brightness does not depend at all on the distance of the observer and it is often nearly independent of the angle of viewing.*

There is now the question of a suitable unit in terms of which brightness may be expressed. The most convenient system is this: consider the illuminating value of one square inch of a surface relative to points lying on a perpendicular drawn from the centre of that square inch.

Confining the attention for the moment to points which are a foot or more away from the surface it is found that the illumination varies with great exactness as the inverse square of the distance. A similar illumination might be obtained by placing a small lamp of suitable candle-power in place of the one square inch of surface. The candle-power of such a lamp is a measure of the brightness of the surface and we may say that the brightness is so many candle-power per square inch. It follows that the illumination at any point in such a case will be the same whether we have one square inch of surface at 3 feet, or 4 square inches at 6 feet, or 100 square inches at 30 feet. The appearance of the surface as viewed from the point is exactly the same in all of the cases, or, stated more strictly, the solid angle subtended is the same. If the view of a surface is limited entirely by an intervening frame or window, the solid angle subtended by the window and the degree of brightness of the surface together determine the illumination received. How far the surface is behind the window or what its inclination may be is of no consequence.

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* From the *General Electric Review* (U.S.A.), slightly abbreviated.

* A surface which exhibits this latter effect perfectly is said to obey Lambert's Law.

Considered in this way, illumination effects are very easy to understand. A few examples will be inserted here to familiarise the reader with these methods.

No. 1. Suppose we have a perfectly even, clouded sky which has a brightness of 2 candle-power per square inch. A room with black walls is lighted solely by means of a hole in the roof, 10 square inches in area. The illumination at a point 6 feet directly below the hole will be $\frac{10\times2}{6^2}$ ft.-candles $= 0{\cdot}55$ ft.-candles. If the hole were 30 square inches in area then the illumination would of course be $\frac{30\times2}{6^2}$ ft.-candles $= 1{\cdot}65$ ft.-candles. However, at 10·4 feet below such a hole the illumination would be $\frac{30\times2}{(10{\cdot}4)^2} = 0{\cdot}55$ ft.-candle, the solid angle being exactly the same as that subtended by a 10-square-inch hole at 6 feet.

Next, consider a point which is not directly under the opening but off in a slanting direction—say 60 deg. with the vertical. The appearance of the hole from such a point will be very different. In fact a hole of 10 square inches will have an *apparent* area of 5 square inches. The illumination at such a point, then, if the distance from the hole is 6 feet, will be $\frac{5\times2}{6^2} = 0{\cdot}28$ ft.-candle. If instead of using the sky we have a large white sheet stretched, say 10 feet above the hole, the illumination conditions in the room will be unchanged, provided the brightness of the underside of the sheet is the same as that of the sky.

The idea to be grasped is this. We can determine the illumination produced at any point by a bright object if we know exactly what is the appearance of that object as viewed by an eye placed at the point in question. The "appearance" includes two factors, brightness and *apparent* size; the latter is identical with the "solid angle" subtended.

No. 2. Metallic tungsten, like all other substances, becomes self-luminous when hotter than about 500 deg. C., and gains rapidly in brightness as the temperature is raised. At a temperature of 2,000 deg. C., its brightness is some 740 candle-power per square inch. Suppose a lamp has a filament of tungsten operating at this temperature, which is to say, at this brightness. The illumination produced at any point can be deduced immediately if we know the apparent area which the filament presents towards that point and also the distance of separation. These two quantities together measure the solid angle subtended by the filament surface, but the solid angle is, after all, derivable directly from the appearance of "view" of the surface from the point in question.

The commonest type of tungsten lamp, viewed from the side, shows twelve straight pieces of wire in "full-face" view. Taking the lengths as 2 inches and the breadths as 0·002 inch, we have $12\times2\times0.002$ square inches approximately as the total area presented to view. The candle-power of the lamp with respect to points opposite the side is therefore $12\times2\times0{\cdot}002\times740$ (at 2,000 deg. C.). The further we go away from the side of the lamp, that is by moving around so as to face the tip, the smaller the apparent area of the tungsten becomes. It is halved by the time we reach 60 deg. away from the side, roughly speaking. The candle-power in that direction is correspondingly smaller. More exact information as to the value for any point could be obtained from a photograph of the lamp taken with the camera lens at that point.

No. 3. The d-c. carbon arc is effective by virtue of a very bright circular patch on the end of the positive electrode. This patch (or crater) is of even brightness and the "distribution curves" for such a lamp are determined solely by the apparent (or foreshortened) area of the crater as seen from different points. The peculiar form of those curves is entirely due to the limited view of the crater as seen from certain standpoints, the obstruction being obviously caused by one or other of the electrodes.

The following Table gives the rough values of surface brightness assigned to familiar surfaces.

Two things should be noticed, the enormous range of values as between different illuminants and the approximate constancy for any particular one irrespective of size of source and consumption.

Table of Brightness Values in Candle-Power per Square Inch.

White paper in bright sunlight ..	15
Coal gas flame	3
Kerosene flame	0·9
Acetylene flame..	30-60
Welsbach mantle (mean)	**30**
Carbon filament	**750**
Tungsten filament (ordinary vacuum practice)	1,000
Tungsten filament (ordinary gas-filled practice)	2,000-7,000
Nernst lamp glower (max.)	3,000
Limelight	2,000
Tungsten filament (special practice)	**24,000**
D-c. carbon arc crater, from 3 amps. upward	**84,000**
The sun at mid-day	600,000

Mirrors.

We are now in a position to appreciate a very useful generalization relating to optical devices. The appearance of any mirror, viewed from any point whatever, must always be what might be called a mosaic of surfaces exhibiting some or all of the brightness values of the surrounding objects.* It will be be granted immediately that this holds in the case of plane mirrors, the "looking glasses" of every-day use. That it holds equally for all curved mirrors may be readily ascertained if a little attention be given to the polished silverware of the table.

The Searchlight.

The searchlight is a familiar example. It is an instrument for producing illumination at great distances and it consists essentially of but two parts, a mirror and a light-source. The latter, as previously explained, is merely a bright *surface* of some size or other.

Suppose we consider the apparatus in use and station ourselves at the point to be illuminated. How may the illumination obtainable at that point be estimated? Why, the case is a simple parallel to those considered already and we shall observe the mirror to be sharply divided into areas *having the brightness values of the surrounding objects.* Here, however, there is the greatest disparity between those values: the carbon arc crater, assuming that to be used, will have a brightness of 84,000 candle-power per square inch while no other object adjacent is likely to have a brightness of more than 1/10 candle-power per inch square. The observer will notice only that area of the mirror which is as bright as the arc crater, all the rest will seem absolutely dark in comparison. The illumination obtained follows immediately, thus if the bright part of the mirror is apparently 20 square feet or 2,880 square inches and the distance is 5,000 feet the illumination must be $\frac{2880\times84{,}000}{5000^2}=9{\cdot}6$ foot-candles. We can also decide at once that if the *whole* apparent area of the mirror is 25 square feet=3,600 square inches, the maximum illumination possible with that mirror at 5 000 feet (when any ordinary carbon arc is used) is $\frac{3600\times84{,}000}{5000^2}=12$ foot-candles. There is thus an evident limitation as regards the illumination attainable at any particular distance and there are two factors in this limitation, the apparent area of the mirror presented and the brightness of the source-surface.

Mirror size is limited by cost and unwieldiness, while source brightness is limited to the values characteristic of the types of illuminant available.

In all of this we have given no attention to the form (curve) of the mirror and the dimensions of the source-surface because these matters are not involved in the considerations given. Nevertheless, the form of the mirror is important because it determines how large an extent of source-surface will be needed in order that the mirror appearance from the point considered shall *all* be bright and hence maximum illumination be obtained. The extent of the source, beyond the degree involved in this last condition, is only significant as determining the lateral range of points enjoying such illumination, in other words the "size of the spot thrown."

It will be readily understood that the only difference between an ideal mirror surface reflecting 100 per cent. and a practical one reflecting say 90 per cent. is that the brightness values observed in the latter are reduced to 0·9 of their original values and consequently the illumination is 0 9 of its ideal value.

The special suitability of the parabolic mirror and the connection between source size and area of the illuminated "spot" are entirely matters of geometry which would be out of place here.

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* For the moment, mirrors will be assumed to have 100 per cent. reflectivity. The actual value for silver is 93 per cent. and the difference may well be neglected temporarily.

Lenses and the like.

The generalization which has been established for mirrors in the foregoing has its exact counterpart in connection with all transparent bodies having polished surfaces, that is excluding all diffusing (roughened, etched or frosted) surfaces. Most table glassware complies with this condition; on looking *through* any part of a water-bottle for example, we see within the outline of the bottle as a frame a mosaic of surfaces showing some or all of the brightness values of the surrounding objects—and no others.*

Once more we can argue that results which hold for the diverse, complicated and arbitrary shapes of tableware may be expected to hold for the simple forms used as *lenses* by the optician.

The Post-card Projector.

As an application of this result we may take the common post-card projector. The usual arrangement comprises a holder for the card, means of illuminating the card—that is to say of rendering the card bright—and a system of polished glass pieces known collectively as an objective.

We are not now concerned with the art involved in giving those glasses the precise curves which result in the post-card picture being reproduced faithfully on the screen or curtain.

The illumination at various points on the screen is what we are interested in and it is very easy to determine what the values will be. If we go close to the screen and look back at the objective, placing the eye well within a sky part of the picture, the whole opening of the objective will show a brightness identical with that of the white part of the card.† Why this should be is not perhaps self-evident but a little argument will make it clear.

That very property of the objective which leads to the faithful reproduction of the picture necessitates that a screen point, which is for example part of the pictured sky, shall derive light only from the corresponding part of the card. If the eye, looking back at the objective from that point could see any part of the objective endowed with the brightness of some separate part of the card (other than that under consideration) this condition would be violated.

Once more, then, we have a relation giving the illumination at any point on the screen. Suppose that from that point the apparent area of the objective opening is six square inches, the brightness of the opening (or the brightness of the corresponding part of the card) is 50 candle-power per sq. in. and the distance of the screen point from the objective is 8 feet, then the illumination is obviously $\frac{6\times50}{8^2}$ foot-candles.

For any particular screen distance the illumination (and hence the brightness of the picture viewed) is determined by the brightness of the card and the effective area of the objective opening. In practice a limit to the brightness of the card is set by the heating effect accompanying the powerful illumination which must be used.

The practical size of the objective is the other limiting factor.

The Magic Lantern.

The magic lantern is related to the post-card projector but is an instrument with much greater possibilities. The difference is due primarily to the different kinds of pictures used; the post-card has the property of scattering light in all directions and consequently merely a fraction of this can reach the objective; expressed in other words, the brightness of any part of the card is very low relative to the intensity of illumination used.

The slide used in magic lanterns is entirely different. It may scatter a little light but there is so much which is not scattered that a vastly better economy is possible as compared with the post-card.

An objective is used, just as in the case of the post-card projector.

There is a combination of lenses somewhat larger than the slide, just behind it. This is followed at an appropriate distance by a very bright source surface Following the preceding line of argument and considering the appearance of the objective as viewed from the screen we find that some or all of the objective opening is as bright as the source while the rest has the negligible brightness of the other contents of the lamp housing. The view from different points on the screen will show that the bright area of the objective is not the same for all, sometimes it lies in the centre of the opening and sometimes it lies more or less to one side. But the *size* of the bright part is substantially constant for all viewpoints.

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* Losses due to reflection and absorption are here neglected.

† We are neglecting certain losses which occur in all lenses: viz., by reflection and by absorption. This applies also to the magic lantern and moving-picture machine but in none of these cases is the effect very large. Furthermore, the corresponding factors are easily introduced by anyone who is interested in the matter.

It is not necessary to repeat the expression for the illumination. The limitations are clearly the brightness of the source and the area of the objective opening *serving any one point*. The question of how much objective area can be provided for this service is an optical one similar to that of providing "working aperture" in a camera or a post-card projector.

It is interesting to note, however, that in the early days kerosene flames were used (9 c.p. per sq. in.). The brightness of this source is so low that large working aperture is essential in the objective to obtain reasonable illumination. Modern illuminants like the special tungsten lamps and the carbon arc have such a vastly greater brightness that the aperture requirement is not hard to meet unless the screen distance (and with it usually the size of the screen-picture) is inordinately great.

The Motion-Picture Machine.

The motion-picture machine is a comparatively complicated piece of apparatus although it is closely related, optically, to the magic lantern. The lantern slide, which is about 3 inches long, is replaced by a similar picture, on celluloid, about 1 inch in length. In present practice the picture is held in place for a small fraction of a second, an opaque shutter then intervenes and cuts out the screen illumination entirely while the picture is being replaced by another, the shutter moves away and the projection of the second picture proceeds for a fraction of a second.* The apparent illumination on the screen is an average of the effects of this regular succession of exposures. The best result which is practicable is an average illumination of about 60 per cent. of that attainable if these alternations did not occur.

Comparing the motion-picture machine with the magic lantern, the same kind of limitations are found to govern the illumination on the screen.

Again we have the working opening of the objective and the brightness of the source. However, if the screen distance and the size of the screen picture are the same in the two cases, the objectives required will be very different. Just as in the case of cameras, where a large plate means a long camera with a big lens and a small plate a short camera with a small lens (if the conditions are at all similar) so in the present case the large lantern slide can be provided with an objective proportionately larger than can be provided for the motion-picture film—equal quality of design being assumed.

As a consequence, the objective opening used in motion-picture work would be small as compared with that found in magic lanterns, and hence the screen illumination would be small, were it not for the fact that the lens makers have pushed the objective design further for the motion-picture outfit and thus reduced the disparity. To some extent this has involved a rather inferior sharpness in the projected picture but to detect this requires a critical examination which motion-pictures do not receive, for obvious reasons.

The typical outfit of to-day, using the carbon arc as the source, is arranged in such a way that no part of the screen gets the benefit of the whole actual opening of the objective. It is possible by using different arrangements to secure that every part of the screen is served by the whole objective opening. The gain in working aperture is sufficient to offset the difference in brightness which exists between the arc crater and specially designed tungsten lamps. This means that in the great majority of cases it is possible to attain the present illumination values if we replace the present arc arrangement by a suitably arranged tungsten lamp and leave the objective as it is.

The injury to the sharpness of the picture which follows the increase of working aperture involved in this change is not such as would be noticed by the lay observer; even if it were so, the present objectives do not represent the limit of design and their cost is a minor item in the outlay which motion-pictures demand,

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* Actual practice is more complicated, in order to prevent flicker.

WORKS LIGHTING.

We notice a series of useful contributions under the above titles by Mr. D. H. Ogley in *The Automobile Engineer* for June, July and August in the present year.

In the first article the general principles of good industrial lighting, as summarised in the Report of the Home Office on Lighting in Factories and Workshops, are explained; data and diagrams being included to illustrate the prevalence of industrial accidents during the dark winter months, and their relation with inadequate lighting. Reference is also made to the necessity of periodical cleaning and maintenance. Curves are presented showing the progressive diminution in illumination during 40 weeks due to deposits of dust on uncleaned lighting appliances which may amount to 15—35 per cent., according to the nature of the reflector. According to these tests the enamelled iron units come out best in this respect. By an actual example of a half-watt installation it is shown that the cost of periodical lighting is small in comparison with the money-value of the saving in light. The former is reckoned to be only 8s. for a period of 24 weeks while the saving in illumination is equivalent to £4 9s. These considerations also apply to depreciation in natural lighting through windows.

Reference is also made to such matters as avoidance of glare, uniformity of illumination, and colour value.

The next article deals with gas lighting, various typical lamps being shown, the manufacture of incandescent mantles described, and the possibilities of high-pressure gas lighting referred to.

The third article of the series, which is to be continued, deals mainly with the planning of installations. A number of illustrations of gas-lighted installations are shown, most of which will be familiar to readers of this journal. There is also a brief summary of the progress of electric lighting, and a comparison is made between half-watt and arc lighting. Mr. Ogley is a member of the Illuminating Engineering Society, and in this series of articles he refers to a considerable amount of information that has been contributed before the Society from time to time.

THE ELECTRIC LAMP INDUSTRY IN JAPAN.

Quoting the *Japan Chronicle*, the *Electrotechnische Zeitschrift* draws attention to recent progress on the part of the electric lamp manufacturing companies in Japan. Shortly after the outbreak of war, Russia is said to have invited orders for 20,000,000 lamps and Japan is filling many orders to that country which formerly would have gone to Germany.

A summary is given of the outputs of various Japanese companies, which, according to the information last available, can turn out more than thirty million lamps. This is sufficient to more than cover the home demand, and in view of probable subsequent extensions it is thought that Japan will be able to export lamps to a much higher figure in the future.

THE GAS INDUSTRY IN GERMANY.

An account of the difficulties experienced by gas works in Germany is given in the President's address to the German Gas Association, which is translated in the *Gas Journal*.

The shortage of coal has led to a demand for restriction of consumption, though it is suggested that this can hardly be expected in the industrial field, and that the only suitable outlet for economy lies in domestic lighting.

An interesting method of procedure is adopted at Crefeld, where 17s. per 1,000 cubic feet was charged for any gas consumed in either November, December or January which was in excess of the consumption during the month of November.

GAS AND ELECTRIC LIGHTING OF THE GENERAL OFFICES OF THE CONSOLIDATED GAS COMPANY.*

By T. Schofield and C. L. Law.

The account given in a recent paper before the Illuminating Engineering Society, U.S.A., by Mr. Schofield and Mr. Law, of the lighting of the above offices presents several interesting features. We have not only the interesting case of gas and electric lighting being employed to light in different sections of the same building. We have also a good instance of the application of both systems of lighting to very similar problems, and a general uniformity of treatment showing how, by the aid of modern lighting appliances, both systems of illumination can be made to yield substantially the same lighting conditions.

In both cases semi-indirect lighting is very largely employed, being used in the main offices, and only supplemented by direct lighting in the less important rooms. Moreover, the design of fixture used in both cases is the same, being merely converted to electric lamps in one case and gas mantles in the other. A further resemblance is secured by the use of distance ignition with the gas lamps, enabling them to be controlled from a distance.

So far as one can judge from the illustrations and the data for the illumination provided, the lighting conditions are substantially the same in both installations. The good features of semi-indirect lighting, avoidance of glare, good diffusion, and uniformity of distribution appear to have beed generally secured. Figures are also given for the brightness of the bowls (approx. 250-600 millilamberts in the case of gas and 500-1,000 in the case of electricity), and as these values are below the brightness of the average white sky, and the units are well up out of the range of view, the effect should be quite satisfactory from the standpoint of avoidance of glare. A comparison of the brightness of the bowl with that of the ceiling above shows that the ratio was invariably within 1 : 60, which appears moderate.

The photographs reproduced in the original article resemble generally those we have published from time to time illustrating semi-indirect office lighting, and appear to give a pleasing effect, a good feature being the choice of a design of the cased glass bowls to harmonise with the decoration of the white ceiling from which they are suspended.

We will now give a few additional details regarding the gas and electrical equipment and some data, referring to representative rooms and selected from the table presented by the authors, showing the conditions of illumination.

Gas Lighting.

The semi-indirect bowls employed are of heavy cased glass, the fixture being finished in yellow bronze. The 24″ fixture is approximately 5′ 5″ in overall length, and contains two 5-mantle inverted burners. The corresponding 16″ fixture is 4′ 1″ in overall length and contains one 3-mantle burner. When lighted the bowls give a soft amber hue. The glassware is arranged on a hinged support, making it easy to replace mantles and undertake cleaning operations.

The fittings are all supported with bronze rods, one of which is used to convey the gas to the burners (thus eliminating any unsightly piping and carrying still further the similarity to an electric fitting). Just before the gas reaches the burner a by-pass connection is taken off. On this by-pass connection a small electro-magnet cock controlling the pilot is placed. At the end of the pilot is the filament igniter, a piece of fine platinum wire which is raised to the ignition temperature by the passage of an electric current (supplemented by the catalytic properties of the wire). The filament is in series with the electromagnet valve, so that if the latter should be damaged or broken, the valve cannot be opened. Fixtures are controlled separately or in groups of two or three from the same button. Current is supplied from a storage battery and motor-generator set in the basement, automatically controlled so as to keep the pressure between 14 and 15 volts. This set also furnishes current for bells, buzzers, elevator signals, &c., throughout building.

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* Notes on a contribution appearing in the Transactions of The Illuminating Engineering Society (U.S.A.), June 20, 1917.

Provision is made for controlling and igniting the fixtures manually in the event of the automatic ignition getting out of order. The direct lighting units are also furnished with electric ignition.

The data in Table I. relating to the illumination in some of the offices are of interest. The illumination was measured in foot-candles in a horizontal plane 30″ above the floor.

TABLE I.—ILLUMINATION DATA FOR GAS LIGHTING.

Room.	Dimensions.		Lighting Equipment.	Illumination.	
	Area.	Ceiling height.		Mean.	Max./Min.
	sq. ft.	Ft. in.		Ft.-c.	
Show Room ..	3,330	15 11	One 24″ semi-indirect fixture per bay, containing two 5-mantle burners. Spacing:—Longl. distance 20′, transverse distance 19′. Bottom of bowl to Floor, 10′ 6″.	4·31	1·8
Book-Keepers' Space	910	12 4½	Ten 16″ semi-indirect units each containing one 3-mantle burner. Spacing:—Longl. distance 10′, transverse distance 9′ 10½″. Bottom of bowl to floor 8′ 8½″.	7·14	1·8
Drawing Office ..	6,345	10 0	Fifty-seven 16″ semi-indirect units, each containing one 3-mantle horizonal burner. Spacing:—Longl. distance, 9′ 3″, transverse distance, 11′. 4 fixtures per bay. Bottom of bowl to floor, 7′ 2″.	7·64	1·4
Board Room. ..	444	10 6	Two 14″ semi-indirect units, each containing one 3-mantle burner. Spacing:—Centre of room, 10′ 10″ apart. Bottom of bowl to floor, 7′ 9″.	3·40	4·2

ELECTRIC LIGHTING.

As regards the electric lighting fixtures it only requires to be said that their design was similar to that of the gas fixtures already described. Dishes varying in diameter from 12″ to 24″ were, however, used.

Some illumination data, similar to those presented above for gas-lighting, are assembled in Table II. The illumination was again given in foot-candles, measured in a horizontal plane approximately 30″ above the floor. (In certain cases the height of the plane was greater but these are not included among the examples given.

TABLE II.—ILLUMINATION DATA FOR GAS LIGHTING.

Room.	Floor Area.	Size of Bay.	Ceiling Fixtures per Bay.	Diam. of Dish.	Lamps in each Unit.	Illumination.	
						Mean.	Max./Min.
	sq. ft.	Ft. Ft. in.		Inches.		Ft.-c.	
Show Room ..	7,200	23 × 18 7	1	24	6—60w.	11·7	4·69
Drawing Office	7,581	23 × 18 7	4	14	4—60w.	8·0	1·79
Corres. Dept. ..	6,656	23 × 18 7	4	14	4—40w.	4·8	1·95
Executive Office	432	—	1	22	6—40w.	2·3	6·13

LAMP POSTS ADORNED WITH A CITY'S EMBLEM.

THE complaint has often been made that the conventional types of lamp posts installed in great cities lack individuality, show few traces of artistic design, and are rarely designed with a view to harmony with surroundings.

This is a problem which cannot be studied in detail at the present time, but should be taken up after the war. Meantime we notice an attempt at such individual treatment in the city of Alhambra, California, which is referred to in *Popular Mechanics*. The lamp posts in this city, which are of a graceful type carrying three diffusing glass globes, were specially designed for the city. The design, which is copyrighted and cannot be reproduced elsewhere, utilises the insignia of the city, namely, a crescent and a star, which is suggestive of the Alhambra Moorish Palace in Spain. The insignia are worked into the arms supporting the lights and also appear on the sides of the base of the column.

POWER DIRECT FROM SUNLIGHT.

In view of the present shortage of fuel, the fascinating problem of obtaining power direct from sunlight, which has often been the subject of investigation, is again being considered. Reference was made to the subject in a paper recently read by Mr. J. F. Crowley before the Irish Technical Instruction Congress.

It is calculated that the power received from the sun on an acre of the earth's surface on a clear day may amount to as much as 5,000 h.p. The problem is to convert this energy into a useful form. Attempts have been made to use the heating effect of the sun to raise steam.

Meantime we notice in the *Electrician* a summary of a paper read by Mr. T. W. Case before the New York Electrical Society, which refers to a possible direct conversion of light into electric energy, and has distinct theoretical interest. In experiments made in Florida it was found that a current is produced when light impinges on a cell containing two copper plates, one bright and one oxidised, immersed in a solution of sodium chloride. The pressure derived from such a cell, about 0·1 volts, is very small, and the current obtained in these experiments from a single cell only about 1-5th of an ampere. But the effect is interesting, and it is conceivable that by using cells of much larger dimension and a greater number of them, a useful source of power might eventually be developed.

THE COLORATION OF ARC LAMP GLOBES.*

By M. Luckiesh.

The purplish tint of arc lamps has been often noted, and it is well known that glasses exposed to sunlight and X-rays may undergo a similar colour-change. The coloration is characteristic of glasses containing manganese, but is not confined to this type. Glasses containing potash, but free from manganese, gradually assume a bluish tinge and those containing sodium a yellowish-green tinge.

From the lighting standpoint, such changes are objectionable because they involve increased absorption. It is of interest to note that the colour is quite unstable and may be caused to disappear by heating with a Bunsen flame. The explanation of such changes is obscure. It is sometimes assumed that the colours of glasses are due to two general states of the metal present. In one state, for example in copper blue-green glass, the metal is assumed to be in solution in the same manner as copper sulphate dissolves in water; in the other state, for example in gold ruby glass, the metal is believed to exist as a colloidal solution. Now manganese is supposed to be present in chemical combination as a salt in a solution of the first kind. It is assumed that radiant energy has the effect of changing the chemical composition of the material, and so producing the purple coloration. The metal, under somewhat similar conditions, has been spoken of as "crystallising out."

Manganese, however, has a certain utility in neutralising the greenish tint normally present in glass containing traces of iron oxide. It is clear, however, that the admixture of manganese leads to increased absorption. For example, if the greenish coloration leads to an absorption of 5 per cent., and the added manganese necessary to neutralise this colour gives an absorption of 6 per cent., then we have, in the total, 11 per cent. absorption. Moreover, there is a gradual increase in absorption as the purple coloration due to the manganese becomes accentuated; in cases examined by the author the transmission has been reduced from an initial 10 per cent. to 25 per cent. due to this cause. In the case of opal glasses the decrease in the coefficient of transmission may be even more rapid owing to the diffusion of light within the material. Few people realise the degree to which this absorption may proceed. The writer has picked up pieces of broken glass from arc lamps which had been in use for some time, and found the transmission to be only one-half that of clear uncoloured glass; on some specimens, in which the purple coloration was pronounced, the transmission varied from 55—85 per cent.

The effect is probably accentuated by illuminants giving much ultra-violet light, but there is ground for thinking that in the case of lamps enclosing tungsten lamps, the effect is mainly caused by sunlight, which may affect ordinary window glasses appreciably. It is well worth consideration whether, for ordinary lighting purposes, glasses free from manganese should not be preferred, even though this would involve a slight greenish coloration.

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* Abstract of an article in the *General Electric Review* (U.S.A.).

THE SPECTRAL ANALYSIS OF DYES AND PIGMENTS.

A CONTRIBUTION by M. Luckiesh to the *Journal of the Franklin Institute** contains some useful data on the colour of light reflected or transmitted by various dyes and pigments. In view of the close attention being paid to dye-manufacture in this country the matter deserves careful consideration.

Of the various methods of analysing colour the most accurate and scientific is spectrum analysis. The use of the spectrophotometer enables not only the reflecting power for light of any particular colour, but also the distribution of reflection or transmission for a pigment throughout the entire spectrum to be readily ascertained. If results are expressed in terms of light of definite wavelengths the results can be checked and reproduced by other observers. On the other hand, if one works only with light transmitted through standard glasses or colour solutions, which do not give absolutely pure coloured light, there must always be some doubt about the reproduceability of the results, and their interpretation, although these methods are more convenient for demonstration purposes.

In addition to the study of visible light the transmission of reflection of infra-red and ultra-violet rays is also of interest, and this can be studied by special instruments such as the bolometer, the thermopile and the photo-electric cell. Admittedly there is less precision attainable in this field, especially in regard to ultra-violet light, where differences in wavelength may produce widely different results according to the use to which such rays are put (*i.e.*, whether for therapeutic, photographic, or chemical uses).

The reflection of coloured surfaces can be tested by allowing strong light to impinge on them and then comparing the reflected light with the incident ray with a spectrophotometer. Mr. Luckiesh presents tables of the reflecting power of various pigments (vermilion, burnt sienna, yellow ochre, chrome green, cobalt blue, etc.) studied in this way. Although having a predominant hue, these pigments reflect quite a lot of light in other parts of the spectrum. Moreover, in an accurate study of such materials there are many special circumstances to be taken into account.

For example, the way in which the pigment is applied has a material influence on its colour-value. If the powdered pigment is given a smooth surface by pressure it does not appear as pure in colour as when it is loosely packed, because in the latter case a greater proportion of the incident light is able to penetrate more deeply into the body and become coloured by selective reflections and transmissions. Similarly, the quality of the fabric to which a dye or pigment is applied is not without influence. Two microphotographs of cotton and silk fabrics impregnated with the same dye are reproduced to illustrate this effect. In general the latter permits the radiation to penetrate more deeply and gives a stronger colouration than in the case of the cotton fibres. The refractive index of the crystals of which a pigment is composed will also affect the penetration and therefore the colour, and the size of such crystals will no doubt depend on the method of applying the solution and its concentration. The effect of concentration has not been very fully studied. The transmission is a simple logarithmic function of the depth of a given solution and its concentration, but the relation varies with the wavelength so that, for an impure colour, the calculations would be rather complex. Values of total transmission are, therefore, best determined by direct measurement.

Coloured glasses may be studied in much the same manner as solutions, though the physics of the operation by which glasses are coloured by metallic ingredients are by no means clear. In some glasses the colour is believed to be due to the suspension of minute particles of metal in a colloidal state. By illuminating specimens obliquely with strong light, and viewing them under a microscope, Siedentopf and Szigmondy have detected the presence of such particles. In other cases the metal appears to enter into a state of true solution, in the same manner as a salt in a liquid solvent.

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* The Physical Basis of Colour Technology, by M. Luckiesh, *Journ. Franklin Institute*, July, 1917.

A determination of transmission or reflection coefficients of a coloured surface or medium respectively must be made with respect to the incident light. Naturally the nature of the emerging light will depend on the character of the light impinging on the surface or solution. A coloured fabric, as is well known, varies considerably in appearance according as it is viewed by daylight, or by light from the arc-lamp, the incandescent mantle, the electric glow-lamp, etc. Even the variations in daylight itself at different periods in the day and year cause such differences. Mr. Luckiesh presents diagrams showing the reflection coefficient throughout the spectrum of pigments by noon sunlight, blue skylight, and tungsten (vacuum) filament lamps. A truly white surface should return a spectrum identical with that of the impinging light, but a coloured medium, exercising selective reflection, will not do so. This quality has been suggested as a criterion of a "white" surface, and there are many materials which, for practical purposes, approach very closely to this condition (such as pressed magnesia, zinc white, etc.). Yet, if the light is made to undergo successive reflections, a difference in tint may be revealed even in the cases of so-called white surfaces. If, for example, a box or sphere is coated internally with a supposedly neutral pigment light entering the enclosure undergoes innumerable successive reflections and transmissions, and the emergent rays may therefore be appreciably altered in spectral composition.

It is also worthy of note that many approximately white surfaces differ widely in their power of reflecting ultra-violet light. Zinc white, for example, absorbs ultra-violet energy very freely. Similarly it has been shown that cobalt oxide is a much better reflector of infra-red energy than zinc white, although for visible rays its reflecting power is vastly less. Again, lead oxide is a much more efficient reflector of long-wave energy than zinc oxide, magnesium carbonate, and other white pigments.

It has been remarked that coloured solutions in general transmit more or less impure light, although in some cases it is possible to get a very narrow band of transmission. It is noteworthy that there is no known dye which transmits only a narrow region near spectral yellow. In cases in which several colours are transmitted with different ease the colour of a solution will depend to some extent on its depth and concentration. In some cases, *e.g.*, fluorescein and uranine, the effect is complicated by marked fluorescence.

OPPORTUNITIES FOR GAS IN FOREIGN LANDS.

In the *Gas Age* Mr. F. J. Koch points out the opportunities for gas in central Europe after the War. At present in these lands houses are lighted almost exclusively by candles, tapers and oil lamps. In the Danube and Balkans the candle is paramount and expensive. Most of the people work on the farms and, retiring very early in the evening require little or no artificial light; but if illumination were more abundant they would doubtless make more use of the evening.

Even hotels rely chiefly on candles. It is customary for a new candle to be placed in every room when a customer arrives; if he should merely light this candle for a minute and then extinguish it he would be charged for the entire candle in the bill.

Oil lamps are also widely used. In the Greek churches the old dim religious light from a single large oil lamp, supplemented by candles is usual, and the streets of the capital of Montenegro are still lighted by oil lamps.

REVIEWS OF BOOKS.

The Range of Electric Searchlight Projectors, by Jean Rey, translated by J H. Johnson, M.I.E.E., Assoc. A.I.E.E. (Constable and Co., Ltd., London. 1917, 12s. 6*d. net ; pp.* 152, 32 *illustrations,* 8 *plates.*)

THE present conflict has greatly stimulated interest in searchlights. Those who have studied the subject are aware of the lack of up-to-date information on the latest developments, particularly on the conditions governing their effective use. The above work deals with an aspect of the matter on which very little has been published. The "candle-power" of a searchlight is to many people a vague term, while the factors determining range are still only imperfectly understood. Prof. Blondel has done much valuable pioneering work in this direction,* and both he and M. Rey have taken up the study of range energetically in France. Mr. Johnson's translation of the latter's work is therefore timely.

The book proceeds in logical sequence, the distribution of light from a projector and the determination of luminous flux being first explained, and the illumination theoretically obtainable from a reflector of specified dimensions calculated. The chapter on the efficiency of searchlights, in which the losses of light due to obstruction, reflection from the mirror, obscuration of the atmosphere, &c., are analysed, breaks new ground, and the same applies to Part II., in which the range of searchlights is fully discussed. Here the reader gains an insight into the many disturbing factors on which effective range depends, and M. Rey is at pains to illustrate each point by worked examples referring to observation of distant fortresses, battleships, gasses of troops, &c., which give a clear conception how these theoretical data may be effectively utilised in war. The book contains a number of valuable plates containing data relating to the range with atmospheric absorption and other factors.

We think that the book should prove extremely useful to artillery officers and others interested in the technical applications of searchlights, while to the illuminating engineer it presents an instructive example of the utility of the conception of flux of light. Mr. Johnson may be congratulated on having brought the work within the reach of English readers. We notice a few slips in translation, most of which, however, are corrected in the *Errata* table, and in view of the complexity of the subject there are some passages which might perhaps be reworded with advantage in the next edition. The printing and paper are good and the diagrams clear, and there is an adequate index.

Journal of the Society of Glass Technology, Vol. 1, *No.* 1, *May,* 1917. (*Published by the Society of Glass Technology. Sec.* : *Dr. E. W. E. S. Turner, The University, Sheffield.*)

DURING recent years we have had to record many interesting developments in the scientific world, and to all of us the need for closer study of certain fields of knowledge has been very clearly indicated. Glass technology offers a good illustration of such a subject. The war has revealed the vital necessity for a more scientific study of the processes of glass manufacture, and the applications of glass in various scientific and optical instruments. In illuminating engineering the matter was early brought to our notice in connection with the difficulties in the manufacture of illuminating glassware, but there is scarcely any field of knowledge into which optics and glass technology does not enter to some extent.

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* *Illum. Eng.*, Feb. and April, 1915.

The formation of a Society of Glass Technology, with its headquarters at Sheffield University, where a special department has been formed to study this subject experimentally, was therefore a welcome step forward. From the first volume issued by the Society we note that it is receiving the co-operation of a number of leading glass manufacturers, as well as professors, Government officials and others interested in the utilisation of optical glass. We observe further that "all persons interested in glass, whether from the point of view of the manufacturer, the distributor, the scientist, the user or collector, are eligible for membership. This wise distribution of interests, which resembles that adopted in the constitution of the Illuminating Engineering Society, should be conducive to most useful work, and the first number of the *Transactions* affords evidence that valuable investigations are already being undertaken.

The original papers contributed to the Society deal with such subjects as British Glass Sands, the Annealing of Glass, and the Influence of Small Quantities of Chlorides and Sulphates in Producing Opalescence. A particularly interesting paper is that by Mr. T. Teisen on the Development of Glass Furnaces on the Continent.

Not the least valuable feature in the Transactions, however, is the section devoted to abstracts and reviews of papers and articles dealing with glass technology, which are classified under five headings. Hitherto, we believe, there has been no similar attempt to collect such literature in this country and the regular presentation of such data should be extremely valuable.

We trust that the formation of this Society will mark the beginning of a new era in glass technology in this country, and we hope that it will meet with well-deserved success. Much of its work is of direct interest to the illuminating engineer, and we feel sure that valuable results would follow from its co-operation with the Illuminating Engineering Society in studying such matters as the qualities of illuminating glassware, both from a manufacturing standpoint and from the practical aspect as distributors of light.

The International Industrial Institute: Safety Engineering Lessons.

We have received from the International Industrial Institute (Home Office, Little Buildings, Boston, U.S.A.) particulars of courses of Safety Enginering, covering the whole field of safety and industrial hygiene and leading to the degree of "Safety Engineer." The authors of the course are the Hon. Dudley M. Holman, who was a member of the Massachusetts Industrial Accident Board from its inception, and Dr. W. H. Tolman, who was the founder and first director of the American Museum of Safety.

We understand that these courses are being encouraged by many experts associated with industrial concerns and the booklet received contains warm expressions of appreciation from many leaders of industry, officials of insurance companies, and others concerned with safety and the prevention of accidents.

That there is need for such a movement is shown by the figures quoted for the State of Massachusetts. In this State alone, 150,000 accidents were reported to the Industrial Accident Board in 1916, and 2,838,448 dollars were paid out in 1915 for compensation and medical treatment. In the whole of the United States, 32,000 accidental deaths in industry are reported annually, over 250,000 men and women are permanently incapacitated by accidents and industrial diseases, and over 3,000,000 are injured by accidents each year. It is estimated that mechanical safeguards will prevent only 10—20 per cent. of accidents. The rest of the problem is educational. Dr. F. W. Loughran, M.D., Medical Adviser to the New York State Insurance Fund, estimates that on the average each industrial worker in the United States loses nine days yearly through sickness; as there are about thirty million workers in the United States, the resulting economic loss, both to workers and manufacturers, can be readily estimated.

We wish the movement inaugurated by Mr. Holman and Dr. Tolman every success, and trust that the variety of accidents in which this journal is primarily interested, *i.e.*, those due to inadequate lighting, will receive special attention.

CORRESPONDENCE.

FLUORESCENCE AND PHOSPHORESCENCE.

Sir,

Dr. Sheppard, in his communication appearing in The Illuminating Engineer for June, contends that phosphorescence, unlike fluorescence, "is associated with the presence of stray or unsaturated affinities due to free, usually metallic, nuclei, of several valency stages, in colloidal or solid solution in the material." And he adds that "this conclusion is not new, but was established by the work of Lecoq de Boisbaudran."

It is true that Lecoq de Boisbaudran sought to establish that phosphorescence (including both phosphorescence and fluorescence) depends upon a pre-existent solid solution. But when Dr. Sheppard continues: "I have obtained evidence in the same sense in reference to calcium tungstate," he is adducing evidence against this savant's contention, for, according to Boisbaudran's school, the whole of luminescence, and not only the phosphorescence of calcium tungstate, is due to undiscovered impurity.*

It is therefore clear that Dr. Sheppard and the authority referred to are using the word "Phosphorescence" in different senses. In the discussion before the Illuminating Engineering Society to which Dr. Sheppard refers, I pointed out that, owing to the relegation of the word "phosphorescence" by Stokes to a side issue, it was no longer permissible to speak of the phosphorescence of phosphorus. Now Dr. Sheppard goes even further, and introduces a definition of fluorescence which will not allow us to speak of the fluorescence of fluorspar (an impure substance)! Yet Stokes himself derived fluorescence from fluorspar, so that his nomenclature is in turn being assailed.

As an illustration of my remark that there is no essential difference between fluorescence and phosphorescence (using these words in Stokes's sense) I demonstrated, at the meeting referred to, the effect of heat upon a typical phosphorescent substance, zinc sulphide, which is both phosphorescent and fluorescent at ordinary temperatures. At about 100° C. this substance was brilliantly fluorescent but no longer phosphorescent. I next showed two specimens of manganiferous zinc sulphide both brilliantly fluorescent at ordinary temperatures; one of these specimens exhibited a brilliant after-glow, the other nothing. Dr. Sheppard's new definition of fluorescence would ignore these phenomena, and is also inconsistent. For example, Dewar* has stated:—

"When ammonium platinocyanide is cooled with liquid air and maintained at this temperature by being immersed in the liquid while still stimulated by exposure to a beam of the electric arc, it continues to glow in the dark with a feeble emission as long as the temperature is kept about −180° C. . . . On pouring off, however, the liquid from the crystals so that the temperature may rise, the interior of the test-tube glows like a lamp."

We see, therefore, that pure ammonium platinocyanide, usually a perfect example of fluorescence and an example conforming with Dr. Sheppard's definition, may, by suitable experimental conditions, be made to exhibit phosphorescence; thus assuredly florescence and phosphorescence represent "a distinction without a difference."

Moreover, Lecoq de Boisbaudran was incorrect in thinking that these nuclei must be pre-existent. They must be existent at the moment of luminescence, even in pure nonvalent neon, and in pure calcium tungstate. Where these nuclei come from when not originally present would present a fascinating study to the photochemist. But the permanent or evanescent nature of the nuclei has little to do with the question, whether or no there is an appreciable "time-lag." I cannot here attempt a full explanation of the origin of the "lag," but it depends on quite another matter. It is briefly an expression of the rate at which (under given conditions of temperature, method of experiment, and mode of production of the substance) association follows dissociation. It is the association that gives rise to the form of energy ultimately transformed by the nuclei into light, but all these associations, &c., are merely important side issues. There is only one type of luminescence—the conversion of an acceptable form of energy, by an acceptable form of nuclei, into light.

In stating that "the luminous response depends largely upon the crystalline solid structure," Dr. Sheppard overlooks the fact that many gases and liquids are brilliantly luminescent. The variety of willemite made by me is a vitreous substance with a conchoidal fracture. Nevertheless it is brilliantly luminescent. I have never seen a crystalline luminescent alkaline-earth sulphide, and I believe that crystallisation has even less to do with luminescence than with transparency. Luminous response depends very little upon crystalline solid structure ; it may come in as an accidental accompaniment of thermal treatment, but is not one of the main issues. Moreover, crystallisation is itself something even more mysterious than luminescence, and to explain an unknown by reference to an even greater unknown is not a move in the right direction.

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* Bruninghaus Ann. Chim. Phys., 20 and 21, 1910.

* Proc. Chem. Soc., No. 142, 1894.

As regards the behaviour of calcium tungstate, I may add that if Dr. Sheppard had used the ultra-violet energy from an iron spark instead of **X**-rays he would have found that even merely dried precipitated calcium tungstate luminesces quite well.

By using calcium molybdate instead of calcium tungstate he will detect the luminescence even more readily. Zinc and cadmium tungstate also luminesce when merely dried, and in all these cases the maximum response to the iron spark is induced at a much lower temperature than the maximum response to **X**-rays.

I am in full agreement with Dr. Sheppard that *pure* calcium tungstate is luminescent, but only by a great number of converging experiments can this be proved, and in order to satisfy the disciples of Boisbaudran's school it must be proved absolutely conclusively.

I also agree entirely with Dr. Sheppard that the after-glow usually exhibited by calcium tungstate is due to an impurity, but the impurity is a "metallic nucleus" that does not contain tungsten. The reducing agency merely liberates the "metallic nucleus" from an innocuous metallo-tungstate, and can be just as well brought about by oxidising or neutral agencies of a selected character, provided of course that the metallo-tungstate is present in the precipitate. So far as I know calcium tungstate cannot be obtained pure by a wet method, though the ever-present impurity can be volatilised off by a furnace method.

Yours, &c.,

A. L. LANDAU,

Luminescence Laboratories,
Cold Chemical Co., London, N,

SIR,

Dr. Sheppard and Mr. Landau have discussed the desirability or otherwise of drawing a distinction between fluorescence and phosphorescence, chiefly from the chemical standpoint.

But from the physical standpoint there is also a means of deciding whether this is indeed "a distinction without a difference." Whatever the chemical basis of these phenomena I imagine it will always be necessary to use some term (such as "after-glow") to denote an effect which is very persistent after excitation. But if it could be shown that fluorescence always involves phosphorescence, *i.e.*, that there is always some after-glow, though the period during which the glow persists may be exceedingly small, this would go far towards showing that the two effects are one.

PHYSICIST.

THE GOVERNMENT AND PUBLICITY.

SIR,

I believe that very shortly the Government will be making a fresh appeal to the public for more money to carry on the War. I would suggest to those responsible for the Government publicity that the people who have the money to invest are the employers and employees. The money is being largely made in the Midlands, Yorkshire, and North of England manufacturing districts, and the best and surest way to get them interestsd is through their Trade Journal, produced for the purpose of promoting their interests and extending their trade at home and abroad.

The *Engineer*, *Engineering*, *Textile Recorder*, *Textile Mercury*, *Dyer and Calico Printer*, *Colliery Guardian*, *Ironmonger*, *Chemist and Druggist*, *Drapers' Record*, *Cabinet Maker*, *British Trade Journal*, *Oil and Color Trades Journal*, &c., to quote a few (according to Mitchell's Newspaper Press Directory there are over 500 Trade Papers published in this country), represent trades in which is invested many millions of capital.

The Trade and Technical Press represent the motive power of English industries, and is therefore one of the greatest assets the country possess, and up to the present time has not been recognised by the Government, except to a small extent, when the Coal Control Committee made an announcement in a few trade papers.

The readers of these papers have the money. Next time the Government is asking for money, why not make their appeal to this great industrial class, the men who have worked hard to make their money and who want a safe investment like the 5 per cent. Exchequer Bonds or the War Loan, through the Trade Press, in addition to the Daily Press ?

Yours &c.,

WALTER JUDD.

TOPICAL AND INDUSTRIAL SECTION.

[At the request of many of our readers we have extended the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]

BRITISH WESTINGHOUSE MOTORS AND GENERATORS IN INDUSTRIAL SERVICE.

A useful Instruction Book (No. 5010/1) issued by the British Westinghouse Electric and Manufacturing Co., Ltd., deals with the installation, operation, care and repair of motors in industrial service. The first section deals generally with installation and contains suggestions regarding unpacking, drying out, foundations, erection, etc. Of special utility are the notes on the mounting of vertical motors, and the arrangement of motors on walls and ceilings, and the hints on the lubrication and care of bearings.

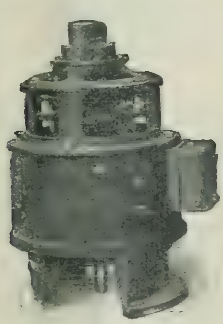

FIG. 1.—Protected Type Vertical D.C. Motor.

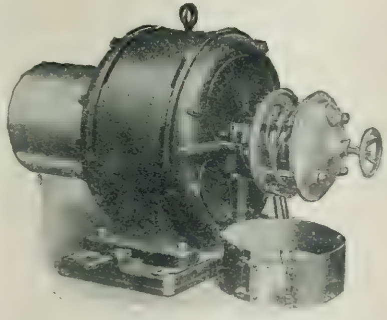

FIG. 2.—Slip-ring Motor with combined brush-lifting and short-circuiting gear.

Electrical connections, and details of operation such as starting and stopping, and repairs are next discussed. D.C. and alternating motors are separately treated.

In the final section of the booklet there are a series of illustrations of typical alternating and D.C. motors, two of which are reproduced in Figs. 1 and 2. The protected type vertical D.C. motor strikes one as a particularly compact and convenient form.

The instructions throughout are clear and definite. We are glad to note this instance of the growing recognition among leading electrical manufacturers that explanations and instructions should supplement catalogue literature. In this way manufacturers can take a useful part in the technical education of the country.

HAWKINS' ELECTRICAL GUIDES.

We are asked to state that the above guides, to which reference was made in our May issue (p. 144), can be obtained from Mr. Geoffrey Parker (29, The Avenue, West Ealing, London, W.13).

THE FEDERATION OF BRITISH INDUSTRIES.

We observe that the Executive Council of the Federation of British Industries has issued a memorandum commenting on the recent Whitley Report on Relations between Employers and Employed. It will be recalled that the latter report advocates the setting up of Joint Standing Industrial Councils, District Councils, and Works Committees representative of employers and employed in each particular industry.

The memorandum issued by the Federation of British Industries recommends that the basis of such a scheme must be trade councils of masters and men. which should have sole power of dealing with agreements and matters of common interest. The main function of district councils should be to act as Courts of Arbitration while the works committees should be voluntary, and should be composed exclusively of employees, preferably elected by ballot. Their duties should be confined to reporting or receiving from the management complaints of any breaches of agreement that occur.

In short, the general policy of these councils should be centralisation of policy and decentralisation of administration.

ILLUMINATING GLASSWARE.

A list (No. 10300-A) issued by the British Thomson-Houston Co., Ltd., contains particulars of ornamental glassware of the Veluria, Alabas, Calla and other types in the form of bowls, spheres and reflectors. There are also illustrations of pleasing designs of dishes of Florentine and Tuscan alabaster. The illustrations of these various units are well executed and the whole get-up of the catalogue is attractive.

In view of the necessity of softening the light from modern high candle-power units by diffusing fittings, it is satisfactory to see that they are receiving such detailed attention and are available in such variety.

PERSONAL.

We are informed that Mr. E. Stroud, who is associated with Holophane, Ltd., and is a member of the Illuminating Engineering Society, has received a commission as Lieutenant in the Royal Naval Volunteer Reserve. Readers will join us in wishing him success in his new work.

The *R. Istituto Tecnico E. Nautico* (Genoa) has issued a bulletin containing the address of Sig. G. Reggio descriptive of the work of the late Professor S. A. Rumi, of Genoa, who was a valued member of the Illuminating Engineering Society. There is also a bibliography of Prof. Rumi's most important contributions to electrical technology. The death of Professor Rumi has already been recorded in these columns, and has been received everywhere with sincere regret.

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Particulars on receipt of post card at either of the above Offices.

F. NORIE-MILLER, J.P
General Manager.

INDEX, August, 1917.

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Signature ....

This Coupon must not be cut out but left intact in THE ILLUMINATING ENGINEER as that being dated, forms the only evidence of its currency.

THE HALIFAX CORPORATION SUB-STATION.

In order to afford a supply of continuous current to the outlying areas of Hebden Bridge and Hipperholme, the Halifax Corporation have recently laid down two converting stations in these districts. The contract for electrical equipment was entrusted to the General Electric Co., Ltd. The converting unit chosen was the 250 k.w. "Witton" rotary converter, together with an oil insulated air-cooled transformer taking in three-phase power at 6,000 volts and generating at 550 volts for traction and 220—0—220 volts for lighting. The incoming feeders are controlled in each substation by "Witton" mistake-proof switchboards. The low-tension boards include both traction and lighting panels, and simple change-over switches are included for applying machines either to lighting or traction. Indebtedness is expressed to Mr. W. M. Rogerson, M.I.E.E., the Borough Electrical Engineer of Halifax, for permission to take photographs and publish a description of the plant'

THE WILD-BARFIELD SYSTEM OF STEEL-HARDENING.

The above process, as exhibited at the Westminster Electrical Testing Laboratory, is being largely applied to the hardening of steel gauges. It had been found previously that in the process of hardening irregularities occur, the diameter and pitch of the screw being affected. Such distortions can only be corrected afterwards with considerable difficulty.

By the Wild-Barfield process, it is claimed, these changes of shapes do not take place. The gauge to be hardened is immersed in a special salt solution heated by the passage of a current through a spiral coil of wire surrounding the cylinder containing the liquid. The correct temperature is checked by observing the "decalescence point" as revealed by sudden loss of magnetism on the part of the gauge. This point is indicated by the deflection of a galvanometer connected to a coil wound round the exterior of the furnace.

The gauge is magnetised by the current flowing through the helix surrounding it, and at the decalescence point the rapid collapse of the lines of force induces a current in the external coil connected to the galvanometer. This current rises to a maximum and then dies away as the non-magnetic stage is reached. The spot of light from the galvanometer therefore deflects and then returns again to zero.

The gauge is afterwards immersed in a special quenching solution of low vapourising point. The ingenious method of controlling the temperature, together with the effect of the special quenching solution in eliminating local evaporation and consequent changes of temperature, is stated to remove the danger of distortion which has previously been a difficulty in gauge-hardening.

CHILIAN SECTION OF THE PANAMA-PACIFIC EXHIBITION.

We have received from Mr. B. B. Sanchez (Santiago de Chile), the Secretary of the Chilian Section of the Panama-Pacific Exhibition, a booklet published by the Chilian Government describing the natural resources of the country, especially in regard to minerals of various kinds.

The information presented will no doubt be of interest to those in this country desiring to enter into business relations in Chile, to whom Mr. Sanchez offers his services.

MERCURY VAPOUR CONVERTERS.

List No. 75b, issued by the Westinghouse Cooper-Hewitt Co., Ltd., describes the construction and use of mercury rectifiers for conversion from alternating to direct current. A special feature is a series of rectifiers for charging telephone batteries.

ELECTRICITY · ACETYLENE

The ILLUMINATING ENGINEER

OIL · GAS

Edited by
LEON GASTER

THE JOURNAL OF SCIENTIFIC
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EDITORIAL.

Industrial Reconstruction and the Whitley Report.

In our last issue we referred briefly to the address on the subject of Industrial Reconstruction, given by Mr. E. J. P. Benn to the Circle of Scientific, Technical and Trade Journalists on September 11th. An important Manifesto on the subject, signed by a large number of well-known men of business and university professors, officers of trade associations and the editors of trade and technical journals, has recently been issued.

A summary of the proposals conveyed in this Memorandum is given on page 243. The fundamental principles on which these recommendations are based were set out in the well-known Whitley Report,* namely :—

(*a*) That District Councils, representative of the Trade Unions and of the Employers' Association in the industry, should be created, or developed out of the existing machinery for negotiation in the various trades.

(*b*) That Works Committees, representative of the management and of the workers employed should be instituted in particular works to act in close co-operation with the district and national machinery.

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* Interim Report on Joint Standing Industrial Councils, issued by the Reconstruction Committee (Cd. 8606, price 1d., published by H.M. Stationery Office, Imperial House, Kingsway, London, W.C.2, and also obtainable through any bookseller.)

On this basis a more detailed scheme of industrial reconstruction is now built up, each trade to be organised separately under a trade council, and all these councils to be responsible to a new Government Department designed to encourage trade and industry.

It is obvious that the application of such a wide-reaching scheme to each particular industry will have to be very carefully considered. The promoters of the scheme rightly emphasise the desirability of retaining the valuable features of our present individualistic system while adding to them the necessary ordered force to ensure greater activity. It seems evident that in many respects there must be room for latitude-- for example, if we take the lighting industry, we can see at once many problems that will need careful study if this industry is to have a Council of its own, entitling members of the industry to a " vocational franchise." We have always contended that there is a common basis for action between different sections of the lighting industry, all of which are concerned with the advancement of illumination in one aspect or another. The platform of the Illuminating Engineering Society has been instrumental in showing how many are the problems in which all these sections are interested. We hope that in course of time illuminating engineering will become a regular profession, and that there will be available a sufficient number of experts in lighting in all its branches to entitle them to a vocational franchise.

At the present time, however, those who make a speciality of lighting in general have also other occupations with which they are professionally identified, and these would have to be considered in determining the vocation in which their franchise would be exercised. It must also be borne in mind that many firms and companies are engaged in various branches of industry, for example, general engineering, besides the supply of lamps and lighting appliances. Gas and electric supply companies, again, are concerned with the supply of these commodities for power and heating as well as for light. It might, therefore, be found preferable to group these interests in a different manner and to provide some form of " cross-connection " to facilitate the treatment of their common ground in connection with lighting.

We are only raising this point to indicate the kind of problems which will necessarily occur in any far-reaching scheme of this kind. In our last issue we referred to the important services which the trade and technical Press can render in promoting discussion on industrial reconstruction; and we conceive that one of their functions will be to raise such debatable points at an early stage in order that they may be threshed out before the moment for decisive action arrives. We should, therefore, welcome the discussion of these debatable points in our correspondence columns. Meantime, there is one principle involved in the scheme which will receive general assent—the need for providing facilities for common action on the part of capital and labour. We are convinced that the industrial future of the country demands much better facilities for an understanding between workers and employers than has prevailed in the past. Joint councils such as those proposed in the Whitley Report are already being formed in some of the most important industries. We feel sure that this intercourse between worker and employer will be productive of good, and that the common ground thus established will not be confined to problems of wages and conditions of employment only, but will include education, research and the interests of each industry as a whole so that members of every grade will have some share in determining its prosperity.

The Report of the Cinema Commission of Enquiry.*

It will be recalled that a paper read by Dr. James Kerr before the Illuminating Engineering Society on February 20th in the present year, on "The Effect on the Eye of Varying Degrees of Brightness and Contrast," referred specially to the problems met with in cinema theatres. In this discussion two representatives of the Cinema Commission of Enquiry, Dr. C. W. Kimmins and Mr. A. E. Newbould, took part and conveyed to the Society an invitation to co-operate with the Commission in regard to questions concerned with lighting.

The writer was subsequently invited to give evidence on this subject before the Commission and accordingly presented a summary of the chief points that required consideration, many of them arising from the discussion referred to above.

The Commission has now concluded its inquiry, and the results are embodied in a comprehensive Report occupying 372 pages. The evidence of forty-two witnesses is reproduced *in extenso* and an exhaustive inquiry is made into the present position and future possibilities of the cinema. Few people realise the extent of the cinema industry, which provides employment for from 80,000 to 100,000 persons in this country, 70,000 feet of film being used every week. It is calculated that the number of attendances at cinematograph entertainments during a single year exceeds a thousand million. It is therefore an obvious necessity for the nature of such entertainments and the conditions under which they take place to be very carefully studied, especially in relation to their effect on the minds and health of children.

A considerable proportion of the evidence is concerned with the moral influence of cinema displays, the conditions of supervision to which they should be subjected, and their educational possibilities. The Commission has done valuable work in collecting evidence on these problems and its recommendation of a State Censorship deserves careful consideration from the authorities. To quote from the Report: "For its own protection as well as for the ensuring of its continued suitability to the nation, the cinema should have the support and the official countenance of the State. We want to place it in a position of real dignity. We want it to be something more than a trade; in fact we wish it to be one of the assets of our national entertainment and recreation." We may add that the importance of the cinema as a medium for conveying ideas to the public and as an educational force also deserves more recognition. The power of the Press is universally acknowledged, but in the cinema there exists a means of communication equally widespread and possibly only second in effectiveness.

The section of the Report in which we are chiefly interested, however, is that dealing with illumination. In weighing the effect of such entertainments on the minds, physique, and eyesight of children, we must recognise that they essentially convey an appeal to the eye, and that, therefore, the methods by which the lighting, both of the screen and the auditorium, is effected are of great importance. The evidence of the writer and Mr. Bishop Harman deals with many points on which there has been much discussion, such as the order of illumination on the screen, the desirable contrast between this brightness and that of surroundings, the influence of flicker, the desirable duration of entertainments, and the distance and angle at which the screen should be viewed. The continuous observation of a brightly illuminated screen amidst relatively dark surroundings is apt to impose a distinct strain on the eyes, and it is common knowledge that the exhibition of unscreened bright lights anywhere within the range of vision of the audience is a cause of mental distraction and visual discomfort. From this standpoint, there is much to be said for the provision of a low general illumination, *free from glare*, while the pictures are being displayed. Lighting and eye-strain form the subject of a special section of the Report, the finding of the Commission under this head being as follows :—

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* "The Cinema: Its Present Position and Future Possibilities" (being the Report and Chief Evidence taken by the Cinema Commission of Enquiry instituted by the National Council of Public Morals, published by Messrs. Williams & Norgate, London, 10s. 6d. net).

> (1) We recommend the adequate illumination of the picture houses whilst the films are being shown.
>
> (2) The best relative illumination of the screen and hall to be determined by a special committee consisting of a few members of the Commission, together with representatives of the Illuminating Engineering Society and technical advisers to the trade. The recommendation of the Hon. Secretary of the Illuminating Engineering Society that the illumination of the hall whilst the display is in progress should be one-tenth of a foot-candle appears to be reasonable.
>
> (3) The continuous display of films extending over some hours is extremely injurious, especially to the young and those with defective eyesight. Hence we recommend that frequent intervals of music, song, or other form of entertainment should be encouraged to relieve the constant strain on the eyes.
>
> (4) We recommend that the front seats should be removed to at least twenty feet from the screen.

On many points involved in the adequate lighting of cinema theatres, such as the avoidance of glare from any unscreened lamps which are particularly distracting to the eye in these circumstances, there is general agreement between experts. It will also be accepted in principle that undue contrasts, either between the screen and surroundings, or the conditions of illumination inside and outside the auditorium should be avoided. The point on which detailed information is chiefly desired is the manner of providing sufficient illumination of the auditorium to prevent excessive contrast with the screen and facilitate supervision by the attendants, without prejudicing the appearance of the pictures. This is a matter which should fall within the province of the joint committee recommended by the Commission, and we feel sure that the Illuminating Engineering Society would gladly co-operate in any investigation that may be undertaken on this point.

As regards the external lighting for cinema theatres, evidence before the Commission advocated that the use of glaring, unshaded powerful lights should be discouraged, in view of the inconvenience of such methods of lighting in the present darkened condition of the streets as well as the desirability of economy in lighting. External lights have since been prohibited by an Order under the Defence of the Realm Act, and it is to be hoped that even after the war these crude and wasteful methods of exterior lighting will be discontinued. The mere display of bright lights cannot be considered judicious advertisement, and attention might be drawn to the theatre much more effectively by the skilful use of screened lights to produce original or artistic effects.

LEON GASTER.

SCHOOLROOM LIGHTING BY GAS.

A PAPER on the lighting of schoolrooms and workplaces, read in February last at the Annual Meeting of the Illuminating Engineering Society in Germany by W. Bertelsmann, presents some features of interest.* The early part of the paper followed fairly familiar lines, but the table presented on p. 236, in which the data has been converted into a form more in accordance with the usage customary in this country, deserves notice.

Dr. Bertelsmann laid due stress on the elimination of glare, the provision of adequate illumination and the value of light tinted surroundings in promoting diffusion. In explaining the calculation of illumination in a room he followed methods on somewhat similar lines to those pursued by Mr. Clinton in his paper before the Society in this country in 1914.† Diagrams were presented showing actual distribution of illumination in rooms as compared with calculated values. These referred to direct lighting, and the agreement between calculated and observed values was in general very close: the additional illumination due to reflection from surroundings being usually within 10 per cent.

In the case of indirect lighting, where so much depends on surroundings, the predetermination of results is not so easy. In the table referred to the author gives some useful figures for direct, semi-indirect, and indirect lighting with gas based on actual installations. It is interesting to note that the values for the specific consumption in cubic feet per lumen on the working plane (*i.e.*, per foot-candle per square foot illuminated) appear to be in close accordance with data presented before the Illuminating Engineering Society in this country. Apparently these are all low-pressure installations. The data bear out the impression that the illumination derived from a given consumption with indirect lighting is not far removed with half that attainable from a good direct lighting installation, while semi-indirect lighting occupies an intermediate position. On the other hand, the diversity coefficient is less than the values recorded with relatively low-suspended units, although apparently not better than the results secured when lamps were mounted near the ceiling. The greatest variation in illumination was recorded for a series of nine shaded low-hanging burners (see *b*, under Direct Lighting), although, as might be expected, this method was efficient so far as specific consumption of gas is concerned, in other cases the higher efficiency secured with relatively powerful units is evident.

In discussing general formulæ for calculating average illumination in a room, Dr. Bertelsmann pointed out that these empirical relations can only be safely employed when the assumptions made regarding type of unit and the shade or reflector are clearly understood. It is of little value to employ a general factor for "shaded" and "unshaded" units, without consideration of the different distributions of light which various reflectors may produce. Similarly, in regard to indirect lighting, one must take into consideration what proportion of the flux of light actually strikes the ceiling, and the presumed reflecting power not only of the latter but also of the walls. The figures given in the table for indirect lighting show the variety in results that may be expected with different installations. It is remarked that the size of the room appears to have a material influence on the results.

Apart from these considerations the author also raises the question whether the mere determination of average illumination is sufficient, especially in schoolrooms. It is little satisfaction to the person occupying the worst-lighted desk to know that the average illumination in the room is up to the standard, if on his own desk the illumination is only a fraction of this average value. In a schoolroom the illumination of the worst-lighted desk should always reach the prescribed minimum value for comfortable work. In planning such an installation for the first time the engineer will, therefore, find it necessary to calculate not only the average value, but the actual illumination throughout the room.

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* Elektrotechnik und Maschinenbau, May 27th, 1917. Also reported in Elektrotechnische Zeitschrift.

† "A Comparison of estimated and observed values of Illumination in some Lighting Installations," by W. C. Clinton, B.Sc., *Illum. Eng.* (Lond.), Vol. VII., 1914, pp. 189—215.

The discussion turned very largely on the merits of direct and indirect lighting. Much of this covered familiar ground, but there were several new suggestions.

Dr. L. Bloch expressed his pleasure in hearing a paper by an expert in gas lighting, in which the principles of illumination were so well explained, and his satisfaction at this instance of the fact that engineers associated with both systems of lighting could co-operate in studying matters of common interest. In regard to indirect lighting he thought that although this system had been widely used with arc lamps, semi-indirect lighting was more suitable for use with half-watt lamps, as it gave a more pleasing effect and yet was instrumental in eliminating

ILLUMINATION DATA FOR DIRECT, SEMI-INDIRECT, AND INDIRECT SYSTEMS.*

Nature of Lighting.	Consumption of gas.	Total mean spherical candle-power.	Mean horizontal illumination.	Specific consumption of gas in cub. ft. lumen (per foot-candle per square foot illuminated) per hour.	Diversity coefficient. Max. /Min.
	cub. ft. per hour.		*Foot-candles.*		
DIRECT :—					
(*a*) *Upright Burners*—					
2 high c.p. units without shade	36·2	567	2·6	0·023	1·61
4 Auer burners without shade	18·1	225	1·63	0·018	3·41
(*b*) *Inverted Burners*—					
2 crown-fixtures, clear glass . .	23·5	522	3·3	0·011	3·02
2 crown-fixtures, opal glass . .	23·5	378	2·4	0·016	4·18
9 low-hanging burners with shades	22·0	468	4·45	0·008	5·08
(*c*) *Lights mounted on Ceiling*—					
Clear glass, with shades . .	23·5	522	4·15	0·009	1·99
Opal glass, with shades . .	23·5	378	2·9	0·013	1·83
Clear glass, without shades . .	23·5	522	3·4	0·011	1·67
Opal glass, without shades . .	23·5	378	2·65	0·014	1·72
High C.P. Units on Ceiling—					
Room 41 sq. feet area : Lamps 7½ ft. high . .	15·2	387	6·5	0·007	1·42
Room 185 sq. feet area : Lamps 11¼ ft. high . .	85·0	2269	6·4	0·0075	1·30
SEMI-INDIRECT :—					
Upright Burners	36·2	567	2·73	0·021	2·06
Inverted Burners	23·5	522	2·46	0·015	3·33
INDIRECT :—					
(1) One-Burner Lamp	36·2	567	2·27	0·026	1·72
(2) Two-Burner Lamp	27·5	288	1·42	0·044	2·13
(3) Four-Burner Lamp . .	25·5	342	1·28	0·032	1·88

* In this table the units have been converted from the metric to the British system, and litres to cub. ft. In converting the data on candle-power and illumination the Hefner has been assumed to be equal to 0·9 international candle.

The data presented are thus expressed in the units customary in this country.

the glare that was apt to arise from their high intrinsic brilliancy if they were injudiciously used. It was commonly assumed that in drawing offices indirect lighting was the ideal system, but he was not sure that this was so. In this work strong shadows were objectionable, but there should be some shadow. He had found, for instance, that in striking circles it was convenient to see a shadow from the leg of the compass, otherwise there was some hesitation in locating the centre from which a circle was struck. He agreed with Dr. Bertelsmann that the average illumination was not the only factor to consider in designing an installation; it was, however, a useful general method of comparing the efficiency of different systems of lighting.

Dr. Wedding also preferred semi-indirect to indirect lighting on the ground that the uniform effect of the latter was trying to the eyes.

Dr. Norden remarked that more precise definition was needed in regard to some of the terms used by the author, for example, in the method of referring to diffused or reflected light (*wiederschein*). Similarly, the terms applied to shadows (" Considerable," " Weaker," " Strong," " Softened," etc.) were not sufficiently defined. Shadow conditions should be expressible in numerical terms, and " shadow-testers," *i.e.*, objects of prescribed definitions throwing a shadow capable of investigation, would yield useful information.

Dr. Heyck argued that semi-indirect lighting did not satisfactorily meet the requirement of eliminating inconvenient shadows. There were two methods of gaining this object, either by indirect lighting or by local shaded lights, the position of which could be adjusted so that the light came from the most convenient direction. Semi-indirect lighting, if there was any considerable direct component, did not completely avoid the direct reflection from polished paper of books and magazines. He considered indirect lighting the best system for a room devoted to reading, and it had been installed in the new library recently equipped in Leipsic.

A NOVEL METHOD OF LIGHTING UNDERGROUND PASSAGES.

An account is given in the *Electrical World* of an interesting method of lighting underground passages, applied to a tunnelled passage through the hill on which stands part of the buildings of the National Lamp Works at Cleveland.

In order to remove the impression of gloom that is apt to characterise such passages it was decided to simulate daylight as exactly as possible, thus removing the sense of being underground. Accordingly artificial windows are arranged at intervals along the corridor, lamps being placed in recesses in the walls, with panes of " cynite " glass in front, which diffuse the light with a minimum of absorption. The lamps are of the 100-watt blue-glass daylight type, giving a close approximation to the colour of natural lighting.

A photograph of the passage shows that the effect resembles daylight illumination from windows very closely. The illumination is not even but this is deliberate in order that the shadows may " break up " the passage and cause it to appear shorter.

The main lighting circuits are arranged for either automatic or manual control. On the automatic system there are door-switches at both ends of the corridor so that pushing the door inward turns on the series of thirty-two daylight lamps and operates a time-switch keeping the lights on for four minutes. A person can easily walk the length of the passage in 4—one to one and a half minutes. Should another person enter the passage while the light is already on the time-switch is automatically set back to its initial position. It is found, however, that throughout the greater part of the day the automatic system is practically continuously in operation and it has therefore become customary to keep the lighting on permanently during the busy hours, only applying the automatic system when the busy hours are over and the passage is little used.

There is also an emergency circuit comprising six 15-watt lamps which are fed continuously from the central station lighting circuit so long as power remains on the lines. Should this power-source fail a relay is provided which would connect the emergency circuit to a storage battery ordinarily used in the laboratory for testing work. There is thus no danger of the passage being left in complete darkness in any event.

PHOSPHORESCENT ZINC SULPHIDE.

The discussion on phosphorescence and fluorescence before the Illuminating Engineering Society last year excited much interest and has led to subsequent correspondence in these columns. It was remarked at the time that information on the chemical conditions responsible for phosphorescence was difficult to obtain, and it is therefore of interest to mention a communication on phosphorescent zinc sulphide which appears in a recent issue of the Journal of the Chemical Society.*

These researches covered widely different methods of preparing zinc sulphide and some interesting results were obtained. In the first place it seems to be recognised that zinc sulphide in the phosphorescent form can only be obtained by the action of heat. Ordinary precipitated zinc sulphide shows no sign of phosphorescence. But by the application of heat, *e.g.*, by deflagrating a mixture of zinc and sulphur, the desired property may be produced. The authors describe various methods of carrying out this process and it is pointed out that the temperature is of considerable importance. Below about 650° C. even prolonged heating produces only a poor phosphorescent effect. Between 650° and 900°, the results are much better, while heating for any length of time above 1100° again produces very poor specimens. The material produced between below 650° was viscous and amorphous, that obtained between 650° and 900° semi-crystalline under the microscope, and that produced at 1100° purely crystalline. It appears therefore that the semi-crystalline state is a desirable condition to produce phosphorescence; the best samples were obtained by heating to some temperature between 650° and 900° for a time not exceeding an hour and a half. The temperature has also an effect on the nature of the after-glow. Specimens produced at 650° give blue phosphorescence, while higher temperatures lead to greens and even yellows.

The effect of small impurities is also discussed in detail. It is known that some substances, such as iron, are prejudicial, even if present in minute quantity; others, such as sodium chloride, increase the phosphorescent effect. The addition of manganese, again, gives rise to a marked golden yellow phosphorescence, and manganiferous zinc sulphide exhibits strong tribo-luminescence (*i.e.*, production of light on friction).

The authors also state, what we believe is the experience of other observers, that the results obtained by radium stimulation do not in any way concord with those obtained by stimulation with light. One interesting fact mentioned is that the phosphorescence of a prepared sample of zinc sulphide may apparently be much diminished by washing with water. It therefore looks as though some material, soluble in water, was necessary to good phosphorescence, and further evidence on this point is furnished by the fact that the conditions of precipitation have an important bearing on the quality of the product. The suggestion is made that the good phosphorescent effect may be associated with the presence of a skin of zinc chloride over the sulphide, producing a condition of strain. This substance would be washed out by water and its removal might cause the diminution in phosphorescence brought about by washing.

The results in this paper are distinctly interesting. Experiments of the kind indicated should be very useful in enabling us to understand the properties on which phosphorescence depends, and possibly to obtain a much more vivid effect than at present.

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* "Phosphorescent Zinc Sulphide" by Elizabeth MacDougall, A. W. Stewart, and R. Wright, Jour. Chem. Soc., Aug. 1917.

THE STATUS AND PROSPECTS OF GAS LIGHTING.*

BY W. J. SERRILL.

IN this address Mr. Serrill referred in general terms to the work of the Illuminating Engineering Society (U.S.A.), and to the activities of its various Committees, but the greater part of the paper related to the present position of gas lighting. After summarising briefly recent steps in the progress of the industry, he turned to various present problems, prominent among which was the question of producing uniformity in gas supply.

UNIFORMITY IN GAS SUPPLY.

Lack of uniformity in the fuel supplied to the consumer is the first obstacle to good gas lighting. It is not essential that one kind of gas should be made throughout the entire country; but when the burners in any one district are adjusted to a particular variety of gas it is highly desirable that the fuel thereafter fed to them should remain constant in quality. In the past two qualities of gas have been general, coal gas and water gas, but in recent years coke oven gas has become an important factor. The differences in these gases in respect of specific gravity, heating power and air-requirements, make the maintenance of a desirable uniformity no easy matter. The chief difficulty, however, has been the effort to maintain a standard candlepower. This quality, now happily in course of abandonment, can only be maintained by varying the proportions of the mixed gases in different seasons, or by processes of enrichment; and it is these changes which cause the variations in the other qualities of the gas essential for incandescent gas lighting.

CALORIFIC INSTEAD OF CANDLE-POWER VALUES.

Candlepower is of value only as regards gas burned with the open-flame burner. It has no value for incandescent burners and the effort to maintain it is actually detrimental. It is one of the bright spots in the future of gas lighting that this incubus is in process of removal.

However, even on this supposition, the maintenance of uniformity of quality demands constant care on the part of the engineer, and there are apt to arise unforeseen difficulties, such as the present shortage of coal and the inevitable consequent changes in the manufacture of gas, which materially alter quality. One other interesting example of practices which act as an obstacle to the development of incandescent gas lighting is given. In the days of flat-flame burners, it was customary for many gas companies to provide such burners free. It was not found practicable to apply this practice to incandescent gas burners and their accessories; but in many cases companies have still continued to supply free flat-flame burners, while making a charge for incandescent ones. This naturally tended to induce consumers to retain flat-flame lighting, and therefore constituted a great hindrance to progress.

Among the important requirements, reference is made to the necessity for constant pressure. Marked irregularities in pressure are a constant source of dissatisfaction, and the variability permitted in the rules of the Public Services Commissions of the various States are seldom unreasonable. Strictly uniform pressures are only possible on high-pressure systems, with a governor on each service, but there are various devices of recent introduction, which greatly simplify the problem of obtaining constancy on low-pressure systems.

Of equal importance is the removal of impurities from the gas, which is greatly facilitated by aiming at uniformity of quality of supply. The discolouration of burners and fittings, walls and ceilings, is largely due to the presence of sulphurous impurities, and when such ingredients can be suppressed, relatively little trouble from this source need occur.

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* Abstract of Presidential Address prepared for the Convention of the Illuminating Engineering Society in the United States: owing to the War the Convention was cancelled, but arrangements have been made for the circularisation of the various contributions prepared.

STANDARDISATION OF BURNERS AND MANTLES.

Reference is next made to the question of ignition and distance control, which still offer a fruitful field for invention, and the standardisation of incandescent lighting appliances. At present little has been done in this direction. As yet no company has made a practice of installing standard burners and mantles free, but in time competition may bring them to it. Meantime a number of companies are using all their efforts to prevent the dissemination of inferior burners and mantles, and to encourage storekeepers to purchase reliable types from the company in their district.

ILLUMINATING ENGINEERING AND GAS LIGHTING.

Mr. Serrill emphasises the great value of illuminating engineering to those concerned with gas lighting, In what follows we quote this section of his remarks in full :—

Generally, poor illuminating engineering on the part of the gas company's salesmen may be fairly cited as one of the handicaps to which gas lighting is subjected. Many causes contribute to this. The salesmen are paid by a method which induces them to increase their sales at any cost, or by a method which induces them to select for sale, not the burners which are best for the location, but those which return the best pay to themselves ; or campaigns are undertaken in which only one type of burner is offered, or the salesmen are insufficiently instructed in the principles of illuminating engineering and their practices would require a more careful study of the conditions than the salesmen have time for. I am offering no criticism of these causes, as many of them are unavoidable or at times a given practice is advisable in spite of certain objections to it. It may, however, be safely said that these conditions tend to improvement. Salesmen generally are receiving more thorough instruction in illuminating engineering; they are, as a class, better experienced in its practice. One of the National Societies has inaugurated an excellent course of instruction for them in this subject. Gas managers, largely through the influence of our own Society's, are more keenly alive to its importance.

During recent years there has grown up a conviction in the industry that gas companies should inaugurate systems by which their employees should visit consumers' premises to examine and maintain their lighting appliances. Some systems of this nature are in operation at the present time.

Mr. Serrill also points out the importance of effective street-lighting by gas, as bringing prominently before the public the possibilities of this illuminant. Much more, he suggests, might be done towards the ornamental lighting of park-ways, boulevards, and important thoroughfares, and if the demand were thus stimulated there would be many opportunities for special artistic fittings.

In regard to those cases in which the same concern or municipality deals both with gas and electric lighting, he remarks that there is a danger that one of the systems may receive more encouragement than the other. Mr. Serrill strongly emphasises the desirability of both illuminants being afforded chances of development in their proper sphere, and the existence of a sufficient element of competition to stimulate both to make advances.

GERMAN ILLUMINATING ENGINEERING SOCIETY.

FOURTH ANNUAL MEETING.

We observe that the fourth annual meeting of the above Society took place on September 15th at the Reichsanstalt in Charlottenburg. The Society has been adopting the method of forming committees on special subjects and a report of the Committee on Practical Lighting Questions was presented by Dr. Lux. Other contributions included papers by Dr. L. Bloch on "Uniform Evaluation or Marking of Sources of Light" and by Dr. Halbertsma on "Diffusion of Light as a means of reducing the Brightness of Artificial Illuminants."

VISIBLE AIR RAID NIGHT WARNINGS.

By An Engineering Correspondent.

The question of a suitable warning of raids in the daytime having been apparently satisfactorily met by the simultaneous sending up of sound bombs all over London, the more difficult problem of warning at night time is now being discussed.

There can be little question that in the daytime an audible signal, which involuntarily compels attention, is preferable to a visible one which would not reach persons indoors and might even be overlooked by persons outside whose view is obstructed or whose mind is occupied by other matters. Moreover, it is difficult to conceive of a form of visible signal which would attract general attention during the day.

There appears to be difference of opinion as to whether it is desirable to rouse everyone by a sound signal in the night, seeing that most people are under cover. It has been suggested that the signal, if any, should be visible, so as only to directly attract attention of those still in the streets, but a strong demand for an audible form of signal has recently become evident.

Most of the suggestions made relate to the use of searchlights. It has been proposed, for example, that the searchlights should be left going all night and only extinguished when a raid is imminent. People who make this suggestion have evidently no conception of the amount of energy taken by a searchlight, nor of the wear and tear involved in continuous use, besides the fact of furnishing an additional guide to the enemy. An alternative proposal has been that coloured screens should be interposed to colour the beams of a few of the searchlights for a short interval preceding a raid; red would probably be the most appropriate colour. This is a more reasonable suggestion. The same object might perhaps be attained by causing a few of the searchlights to oscillate violently through their complete range of movement across the sky during a short period, or by using flashing shutters or other devices to give an intermittent "winking light. Yet another proposal is that red flares or rockets, instead of sound bombs, should be sent up.

One difficulty that is not generally recognised by the public is the high luminosity of the sky in full moonlight, when aeroplane raids are most probable, other conditions being favourable. The brightness of some parts of the sky is of the same order as that of a white surface illuminated by full moonlight, in certain atmospheric conditions may even exceed it. In these circumstances the beams of searchlights, are not very noticeable, and even coloured flares, unless very numerous and powerful, might not be easily visible from a sufficiently extensive area—so as to give a general warning.

If recourse is had to local warning devices, *i.e.*, constables on cycles carrying "Take Cover" notices, the question of the illumination of such notices by portable lamps, and the erection of luminous signs capable of being switched on at any moment is worth consideration. A method which, it is understood, is receiving attention is the use of illuminated motor cars, and omnibuses, carrying the words "Take Cover" or "All Clear" as the case may be, to patrol the main thoroughfares.

According to the *Evening Standard*, Bermondsey is adopting measures of its own for dealing with the problem. It is stated that small blue-colour electric lamps are to be displayed on the tops of the flagstaffs at the Bermondsey and Rotherhithe Town Halls, so long as all is clear and no warning of a raid has been received.

On the receipt of a warning the blue lamps will be cut off and red lamps lighted instead, until the "All Clear" notice is received. Should a raid take place in the day-time a red flag with the words "All Clear" on it will be shown at the two town halls as soon as the official notice is received that danger is past.

Assuming that the exhibition of lights at night is considered dangerous by the authorities, one would imagine that objection might be taken to local expedients in the form of coloured lamps on public buildings. This objection would be greatly diminished if all the rays of light were screened above the horizontal, but the method obviously requires supervision and a uniform procedure should be adopted in different localities. One may question, however, whether this form of warning would be visible over a sufficiently large area to be worth while, unless the lamps were exceptionally bright.

With regard to the exhibition of a red flag in the daytime it seems a pity to depart from the customary association of the colour red with danger; the red flag would be more appropriate as a warning, and another colour (yellow, say) to indicate "All Clear." Another objection to the device is that it is usually difficult to read letters on a flag at any distance; especially when the flag is drooping on a calm day with little wind—such as would be probable in the event of a raid.

Appropriate notices, indicating places where shelter could be obtained during a raid also deserves consideration. Black letters on a yellow ground would answer this requirement as well as being easily visible from a distance.

In order to render the notices conspicuous by night artificial illumination, by sources completely screened from the eye, might be provided—at all events outside all buildings where gas and electricity are available.

LIGHTING ECONOMIES IN BERLIN.

According to Reuter the Berlin authorities have published a statement that the dearth of coal makes it indispensable to stop lighting the steps of halls, a proposal which is open to criticism on the ground of interfering with safety, and which would, presumably, have a very small influence on coal consumption. Houses in Berlin, it is also stated, are to reduce the lighting to a minimum where lighting is indispensable.

FACTORY LIGHTING AND OUTPUT.

In an article in the *Electrical Review and Western Electrician*, Mr. J. J. Kirk quotes an instance of a factory, namely, that of Horn Brothers' Manufacturing Co., in Chicago, in which improved illumination has had a marked effect on output.

The original lighting system was inadequate for the demand for increased production, and the spoilage, especially during the latter part of the day, became excessive.

Mr. W. F. Horn, in referring to the satisfactory nature of the new installation, states that production has been increased by 10 per cent., and spoilage has been completely eliminated. All this he considers to be due to the better artificial lighting of the plant.

INDUSTRIAL RECONSTRUCTION.

An important Manifesto on industrial reconstruction has just been issued bearing the signatures of more than 40 well-known business men, university professors and engineers, a still larger number of officers of representative Trade Associations, and the Editors of a variety of technical journals.

The first essential in any scheme for the fuller development of industry is the co-operation of labour, and the Manifesto accordingly invites the workers cordially to join with the management in the self-government of industry and gives them an equal status and responsibility on the controlling body.

The promoters of the movement attach much importance to the support of the trade Press. Close upon seventy powerful trade and technical journals have signified their general approval of the scheme and their influence on manufacturers and traders will naturally be great.

It is stated that a meeting is to be arranged shortly for the further explanation of these proposals. In the meantime all inquiries on the subject should be addressed to the Secretary Mr. F. H. Galton, Benn Bros. Ltd., 8, Bouverie Street E.C.

With a view to increasing national output and developing industries the following steps are regarded as necessary :—

(1) The mobilisation of each industry for common action.

(2) A greater degree of co-operation between manufacturers.

(3) Co-operation between Labour and Capital and the avoidance of industrial strife.

(4) A more complete association between scientific institutions and traders.

(5) Education better adapted to commercial needs.

(6) Each industry to be studied as a whole and freed from unnecessary internal competition.

(7) Every trade to present a united front to foreign competition.

(8) Output regarded as a duty by both capital and labour.

(9) Encouragement by the Government of the activities of traders with a minimum of interference.

It is therefore suggested :—

(A) That a National Organisation, on lines suggested by the Whitley Report should be established which will retain all the sterling qualities of our present individualistic system and add to them the necessary ordered force to ensure greater activity.

(B) That such an organisation will need to provide for the representation of all classes of persons engaged in a given industry.

(C) That industry should, therefore, be enfranchised and every man and woman, employer and employed, given a vocational or trade vote by means of which this representation would be effectively realised.

(D) That every citizen should have the right to register with some approved Trade Association, or Trade Union, and thus an Industrial or Vocational Register properly classified would be produced.

(E) That Trade Councils should be elected in each industry from the Trade Associations and the Trade Unions, Such Councils, elected upon a truly representative basis, would be able to speak in the names of the whole of their respective industries.

(F) That all questions as between Government and a given trade should be delegated to the Council of the Trade, who would have powers to deal with them.

(G) That questions of output, education, trade schools, scientific research, export, wages, profits, markets, tariffs, etc., should be settled in each trade by the Council of that trade, and national funds spent upon these matters dispensed through the Trade Councils

Finally the Manifesto puts forward a scheme of industrial reconstruction embodying the above features. A vocational franchise would make possible the organisation of each trade separately under a Trade Council composed of capital and labour. A Government Department should be established to promote and encourage trade, and to create representative Trade Councils in every trade, and should be assisted by an Advisory Council consisting of the Chairmen of all the Trade Councils. Such a scheme would permit the decentralisation of a large proportion of the national work now attempted by Government Departments.

THE ORGANISATION OF ENGINEERING TRAINING.

At a gathering of representatives of the Press at the Institute of Journalists on Sept. 27th, a preliminary account was given of some proposals for the better organisation of engineering training. Mr. L. Gaster, Chairman of the Circle of Scientific and Technical and Trade Journalists, presided.

The meeting was addressed by Mr. A. E. Berriman, Chief Engineer of the Daimler Co., Ltd., Coventry, and Mr. A. P. M. Fleming, of the British Westinghouse Electric and Manufacturing Co., Ltd. (Manchester), the honorary organisers of a meeting called to discuss this subject at the Institution of Civil Engineers on Oct. 25th.

Mr. Berriman explained that while some of the leading engineering firms were arranging adequate courses of instruction for their employees, there were cases in which the conditions of apprenticeship were not satisfactory; what was needed was some general supervision for ensuring that all engineering workers were properly trained. This matter was of urgent importance if the national supremacy in engineering industries was to be maintained. At the forthcoming meeting the question of establishing a central organisation for improvement in and better co-ordination of engineering training would be discussed and a proposal made for the appointment of a representative committee of engineering and educational interests to initiate action. At present no actual scheme exists but the need is recognised by leading manufacturers. Educationists have also expressed themselves in cordial agreement with the idea in principle.

It is greatly to be hoped that the forthcoming meeting will result in definite action being taken. Meantime the honorary organisers have taken a judicious step in bringing the matter before the notice of the Press, which is in a position to render very effective aid in making this matter widely known.

CORRESPONDENCE.

CO-OPERATION BETWEEN THE BRITISH GOVERNMENT AND THE TECHNICAL PRESS.

Sir,

Though we are far from desiring to see the British Government everywhere adopting or imitating the innovations of allied or other Governments, we think the Premier might well take a leaf out of the book of Governor Whitman, of New York State. The Governor recently met in conference the editors of the various technical journals in the State, desiring to get reliable evidence upon questions of mechanical production, transport, coal and timber conservation, the provision of machinists and toolmakers, and other vital factors essential to the successful prosecution of the war. As a result, the Governor has now a Committee of five editors acting in an advisory capacity.

Perhaps no class in the community has its fingers more completely upon the pulse of British industries than the men who so worthily and efficiently edit our Technical Press, and we feel sure they might with advantage be called in to the State councils where accurate information is above all things essential. At such a time as this, when, to take only three important branches of public service, the Air, Agricultural, and Marine Departments, there is urgent need for the wisest and sanest counsels as well as driving forces, we think nothing but good could come by the introduction of editorial assistance.

Yours, etc.,

C. W. Brett,

Managing Director and General Manager,
Barimar, Ltd.

REVIEWS OF BOOKS.

ILLUMINATING ENGINEERING PRACTICE.

A series of twenty-two lectures, arranged by the Council of the Illuminating Engineering Society (U.S.A.) and delivered at the University of Pennsylvania, September 20th—28th, 1916 ; *published in volume form by the McGraw Publishing Co.* (*New York*), *and available from the Hill Publishing Co., Ltd.* (6-8, *Bouverie Street, London, E.C.*). [578 *pp.* ; 5 *dollars.*]

It will be recalled that in the autumn of 1910 a course of lectures was arranged, under the auspices of the American Illuminating Engineering Society, by the Johns Hopkins University (Baltimore). This course dealt mainly with fundamental principles. The series of lectures now issued is supplementary to the Johns Hopkins course, and contains a great deal of information on present practice in illuminating engineering, which has become much clearer and more definite during the six years intervening between the two courses of lectures.

We observe that the lectures were well attended, 180 full course subscriptions and 59 tickets to individual lectures being taken. The lectures were supplemented by an exhibit illustrating modern methods of illumination (of which a short illustrated description is given), and visits to various localities of interest to lighting experts.

In what follows we propose to give a brief summary of the contents of these 578 pages. The matter in the volume is arranged in orderly sequence, and there are many diagrams and illustrations. Some of the line diagrams, especially those applying to electric lamps, are excellent, and Mr. Ryan's lecture is illustrated by a number of the familiar colour-plates showing the decorative lighting at the Panama-Pacific Exhibition. The text is presented on paper without shine, and the illustrations on mat art paper—a good arrangement that has been widely adopted in connection with the publications of the American Illuminating Engineering Society. Some of the illustrations of models on a small scale displayed at the exhibit accompanying the lectures are also of interest ; notably one contributed by the Electrical Testing Laboratories to show the characteristic features of street lighting.

At the conclusion of the volume there is an adequate index, and at the conclusion of some of the lectures are useful series of references to the literature of the subject dealt with.

We will now attempt to give some idea of the contents of the volume, although it is naturally impossible to do more than give a brief sketch of this large amount of matter in the space available.

Illumination Units and Calculations.

The first lecture by Mr. A. S. McAllister deals appropriately mainly with units and symbols, the series of definitions framed by the Illuminating Engineering Society in the United States being reproduced. In the explanatory matter special reference is made to calculations of natural illumination from the sky, a subject which lends itself well to illustrating the conception of brightness. The distribution of light from illuminants, and the use of the polar curve, and the Rousseau diagrams enabling the flux of light and the mean spherical candlepower to be determined are explained, and there are some general remarks on calculations—a subject which is also treated in subsequent lectures. In order to illustrate the part played by reflection from surroundings a calculation is given for a room of specified size, the flux of light impinging on walls and ceiling being determined and the utilisation factor (*i.e.*, the percentage of the total light falling on the working plane) deduced.

Interior Illumination.

The second lecture by Messrs. J. R. Cravath, Ward Harrison and R. ff. Pierce deals with interior illumination, and follows naturally after the preceding one. A table is given for the output of standard American tungsten lamps, and we are reproducing this as illustrating how such lamps are now being rated in lumens. The output in lumens by cub. ft. per hour or per gallon respectively for various other illuminants, oil, gas, acetylene, etc., are also given. We notice that modern gas lamps with outputs of 400—3,000 lumens (say 32—240 m. sph. c.p.) are stated to yield 200—325 lumens per cub. ft. per hour. Presumably this refers to low-pressure units. A third useful table gives the conversion figures when brightness is expressed in various ways (c.p. per sq. inch, equivalent foot-candles, millilamberts, etc.). This should be useful, as the latest methods of expressing brightness are not yet very widely known.

Reference is also made to the effect of deposits of dust in causing deterioration in illumination, and curves are presented showing that, as a result of one month's neglect, a loss in light of 15—30 per cent.

Table I.—Lumens Output of American Tungsten Incandescent Lamps (July 1st, 1916), operated to give an average rated life of 1,000 hrs. (J. R. Cravath, Ward Harrison and R. ff. Pierce).

Watts.	Watts per mean sph. c.p.	Lumens per watt.	Total lumens.
	105–125 volt Mazda B Lamps.		
10	1·67	7·5	75
15	1·47	8·55	128
20	1·41	8·90	178
25	1·35	9·30	234
40	1·32	9·50	380
50	1·31	9·60	480
60	1·28	9·80	590
100	1·22	10·3	1,030
	105–125 volt Mazda C * Lamps.		
75	1·09	11·5	865
100	1·00	12·6	1,260
200	0·90	14·0	2,800
300	0·82	15·3	4,600
400	0·82	15·3	6,150
500	0·78	16·1	8,050
250	0·74	17·0	12,800
1000	0·70	18·0	18,000

* Gas-filled. N.B.—220 volt lamps are about 10 % less efficient

may be experienced, according to the type of the reflector. Next there is a summary of the chief varieties of glare (from exposed sources, reflection from shiny materials, etc.), and the view is expressed that the contrast between the brightness of objects in the field of view should not exceed 100 : 1. A table is presented summarising the amount of illumination required for various processes and some general remarks are made on the procedure to be adopted in designing the illumination of an interior.

TABLE II.—CONVERSION TABLE FOR BRIGHTNESS VALUES.

Values in units in this column multiplied by conversion factor equal values in units at top of column.	Candles per sq. cm.	Candles per sq. in.	Candles per sq. metre.	Candles per sq. ft.	Lamberts, apparent lumens per sq. cm.	Foot-candles, apparent lumens per sq. ft.	Millilamberts.
Candles per sq. cm. ..	1	6·451	10000	929·03	3·14	2918	3141·6
Candles per sq. inch ..	0·155	1	1550	144	0·4867	452	486·7
Candles per sq. metre	0·0001	0·00064	1	0·929	0·00031	0·292	0·314
Candles per sq. foot ..	0·00108	0·0069	10·7	1	0·000339	3·14	3·391
Lamberts (apparent lumens per sq. cm.)	0·318	2·054	3180	295·8	1	929·03	1000
Foot-candles (apparent lumens per sq. ft. ..	0·000343	0·00214	3·40	0·318	0·00108	1	1·076
Millilamberts	0·000318	0·002054	3·180	0·2958	0·001	0·929	1

EXTERIOR ILLUMINATION.

The principles of exterior illumination are dealt with in a similar manner by Dr. Louis Bell, who classifies streets according to the chief purpose to be served, and suggests appropriate minimum illumination values. These are substantially similar to those suggested in the Standard Specification for Street-lighting drawn up in this country. Dr. Bell is inclined to prefer single units to clusters, chiefly on account of the greater attention the latter require. Powerful units of the order of 1,000 c.p. should not be placed lower than 25 ft., and 30 ft. is suggested for large squares. Such units should be equipped with diffusing globes. Lighting units of more moderate candle-power, 100—300 c.p., in many cases also require screening, and are usually placed at a height of 15—20 ft. Lamps of smaller output than 100 c.p. do not in general require screening. As regards the diversity factor a variation in illumination of 1 : 10 can only be attained with special efforts and values ranging from 1 : 25 or even 1 : 50 may occur in an apparently well-lighted street.

Turning next to flood-lighting Dr. Bell suggests the formula $E = \frac{4\pi\omega\eta}{\pi\gamma^2} = \frac{4\omega\eta}{r^2}$ for determining the illumination in foot-candles derived on a surface illuminated by a beam. If the section of the beam is elliptical the formula $E = \frac{4\omega\eta}{ab}$ may be substituted. In these formulæ :—

η =the specific efficiency of the source, *in its reflecting system*, $= \sigma\rho\kappa$.

ω =watts consumed.

σ =specific output of source in spherical candles per watt.

ρ =coefficient of reflection of the mirror surface.

κ =percentage of total sphere effective, *i.e.*, the percentage of the total flux from the source which impinges on the mirror.

Finally there are some remarks on the use of coloured light for decorative purposes, as exemplified by the San Francisco Exhibition.

MODERN PHOTOMETRY.

The next lecture by Dr. C. H. Sharp on Modern Photometry contains a general survey of recent work on the flicker photometer, Crova's method, and physical photometers. The position of flame standards such as the Pentane lamp is illustrated by appropriate diagrams, and a form of portable electric standard, which seems to meet a distinct need for reference work, is described. A considerable amount of attention is given to the Ulbricht sphere which appears to be now systematically used for obtaining the flux of light in lumens from incandescent lamps by, among others, at least two laboratories, the Bureau of Standards and the National Lamp Works of the General Electric Co., U.S.A. Special arrangements have been made to facilitate the rapid interchange and testing of such lamps, and, in view of the recognition of rating in lumens, the method is worth notice. The Sharp and Millar illumination photometer is described and also various adjuncts, such as the compensated test-plate designed to give consistent results independent of the angle of incidence of the light.

Another special section of photometry covered is daylight measurements and determination of brightness. A double photometer is shown enabling measurements to be made simultaneously of the general unrestricted daylight illumination, and the illumination actually obtained at a given spot; from this the "daylight factor" is readily determined. Other special points are the photometry of gas-filled lamps, measurements of reflection and transmission, and tests of projection apparatus. The lecturer took the view that searchlights (involving merely a source and a parabolic mirror) can be treated on the assumption that inverse square law holds at reasonable distances; but this may not apply to an automobile headlight where we have also a lens, where an image of the filament is often produced, and where tests must often be made at relatively short distances away.

LAMPS AND LIGHTING APPLIANCES.

There is next a group of three lectures by G. H. Stickney, R. ff. Pierce, and W. F. Little respectively, on "Recent Developments in Electric Lamps," "Recent Developments in Gaslighting," and "Modern Lighting Accessories."

The data on electric lamps are very well assembled and illustrated. Illustrations of a typical series of gas-filled lamps are shown, and the lecturer explained by the aid of diagrams the chief improvements in design since 1910, namely, (A) drawn tungsten filaments, (B) coiled filaments, (C) concentrated filaments, (D) chemical "getters," and (E) gas-filled construction. Other electric illuminants, such as arc lamps and mercury vapour lamps, are treated in detail, the method of showing the polar curve of each along with a diagram of the lamp being very effective. There is a detailed schedule of tests on arc lamps, comprising efficiency, life of carbons, &c.

Mr. Pierce shows by microphotographs the difference in structure of cotton, ramie, and artificial silk mantles, and illustrates diagrammatically the relation between the percentage of ceria and the candlepower for old and new mantles. Burner-design is dealt with in a general manner, and some attention is given to distance control and electromagnetic valves. Some typical semi-indirect gas fittings are shown.

Mr. Little discusses fully the materials used in globes and reflectors, and the properties of various kinds of glass. A table is presented showing the percentage of light reflected, transmitted, and absorbed by a variety of glasses with the ray incident at 20°. Similar data are given for the reflection of polished metals and other surfaces (*e.g.*, corrugated mirror, 80 per cent.; polished aluminium, 67 per cent.; mat porcelain enamel, 73—79 per cent.). One interesting point mentioned is that gelatine, though apparently colourless and transparent, is appreciably more absorbent to the blue end of the spectrum than is clear glass. The chief elements in reflector design are discussed, and polar curves, showing the distribution of light from a variety of types, presented.

LIGHT PROJECTION.

The last lecture we shall refer to on this occasion is that by E. J. Edwards and H. H. Magdsick, on "Light Projection." Curves obtained from typical headlights are given, and a couple of tables are made out summarising the regulations of different States for automobile and locomotive headlights respectively. The former stipulate, as a rule, the range of the beam (usually 200 feet), while the latter require a certain candlepower, usually about 1,500. There is also a brief discussion of the searchlight proper and of lens-signals and lighthouse equipment, and a number of examples are given illustrating the use of flood-lighting to illuminate monuments and public buildings. Finally, there is an interesting analysis of the loss of light in a typical cinematograph projection apparatus; in one example given, only 775 lumens reach the screen out of 23,600 generated by the lantern (approx. 3 per cent.).

(*To be continued.*)

Trade Fallacies, by Arthur Kitson. P. S. King and Son, Ltd., London. 1917. *pp.* 286.

In this work Mr. Kitson deals with a very complex subject, on which there have been very divergent opinions expressed by economists from time to time. He is of the opinion that the legal tender and Bank Charter Acts have had undesirable consequences, and that the conception of credit as based on a gold reserve is a mistaken one. It was not infrequently assumed before the war that a nation which lost all its gold supply would inevitably go bankrupt. It would be as absurd, Mr. Kitson suggests, to argue that if there should be a famine in paper, and it therefore became impracticable to print railway tickets, all the railways of the country would have to cease operations. Gold is only a token, and in times of war its place can be taken by paper currency to a very great extent; in fact Mr. Kitson suggests that so far as home trade is concerned paper is all that is necessary. In times of national emergency nations invariably cease to depend on a gold reserve; their ultimate reserve is the national production.

The author also draws a distinction between British and German systems of banking. The former, he says, is based rather on finance and usury, the latter on production. The British system, while having financial advantages, has industrial drawbacks. To some people it will come as a shock to find that Mr. Kitson does not seem to see any great drawback to the multiplication of paper currency. The creation of paper notes in vast numbers is, he thinks, at least preferable to floating large loans.

Mr. Kitson's book, which is presented in very readable style, certainly provides food for thought, and may lead many people to review their present views on economics and finance.

Illuminating Engineering Society (*U.S.A.*) *Transactions Vol. XII., No. 5, July 20th,* 1917.

The copy of the above *Transactions* last received contains two interesting communications on "Gas and Electric Lighting of the General Offices of the Consolidated Gas Co.," by T. Schofield and C. L. Law, and on "Maintenance of Residence Gas Lamps," by H. H. Newman.

There are also several announcements of interest in the "News Items," including the list of members of the National Committee on Gas and Electric Service, which has been formed to co-operate with the Government in the conduct of the war. On this committee sixteen gentlemen prominently connected with the leading gas and electrical undertakings in the United States are taking part, and it is gratifying to note this fusion of gas and electric interests in the national interest. This body will act as an Advisory Committee to the Council of National Defence.

Among other features of interest in the number are a brief history of the aims and work of the Society and the "Illumination Index," which contains a list of the chief current papers and articles dealing with lighting and illumination.

There is also a review of the activities of the various committees working under the Society, including one dealing with Safety Limitations. This Committee is apparently dealing with matters relating to illumination and traffic. In view of the keen interest being taken in such questions in this country its deliberations will be watched with interest.

We note that Mr. G. H. Stickney will follow Mr. Serrell as President of the Society, and will take up his duties at the commencement of the new session on October 1st.

General Electric Review (*August,* 1917).

This issue contains a variety of articles dealing with widely different aspects of electric technology, such as the Pliotron oscillator, Charging Storage Batteries for Electric Vehicles, and the Comparative Costs of Developing Power for Pumping in the Oilfields. We also notice general contributions by E. W. Rice on, and H. W. Buck dealing with, the position of the engineer in national affairs, and in the prosecution of the war, while the fuel problem is the subject of editorial comment. An article by M. Luckiesh on the Colouration of Arc Lamp Globes was noticed in our last issue. The front of the cover carried an effective illustration, showing the use of flood-lighting in guarding the Queensborough Bridge, New York City.

"UNDERSTANDING THE LUMEN."

We have received from the British Thomson-Houston Co., Ltd., a note, under the above title, in which an analogy is drawn between the behaviour of a pump sending out so many gallons of water per minute and a source of light emitting a certain, unevenly distributed flux of light. In view of the interest now being taken in the method of rating lamps in lumens, we are reproducing this explanation, which is as follows :—

The term "lumen" is becoming more familiar to all branches of the electrical trade, and is now in use by the leading manufacturers of Great Britain as the rating for expressing the luminous output of a lamp in place of candlepower.

A lamp may be regarded as a pump, which uses electricity to pump light out from it in so many different directions that the numerous streams (or beams) form a solid "flood" or "flux" of light. Some of the beams, however, are pumped out with a greater force than others, which causes the lamp to give a stronger light in some directions and no light at all in others. The force or strength of the beams in any one direction may be taken to represent the candlepower in that direction. It is manifest, therefore, that this candlepower (expressing the one-direction force of beam) cannot be a really accurate full measure of the amount of light that is being pumped out by a lamp in all directions.

With the old method of rating lamps, by expressing the light value in candlepower, we simply stated the average force of all the beams pumped out from the lamp in one direction, *i.e.*, the horizontal direction (with the lamp hung tip down). No consideration was given to the light pumped out in other directions. One might have two lamps of the same candlepower, one of which gave little or no light in other directions than the horizontal, while the candlepower of the second lamp was a minimum in the horizontal direction. Inasmuch as lamp filaments are now being made in numerous complicated shapes and forms, each form producing different distributions of light; and still further, as few lamps are now being used except with shades or reflectors which modify the distribution of light still more—realising all this, some other rating than a mere one-direction intensity is necessary properly to express the actual light output given by a lamp.

For these reasons the lumen has been adopted, as it expresses in an accurate way the value of the total light flow from the lamp just as a unit of water pumped is expressed accurately by the gallon flow per minute. We can say, "This lamp generates 600 lumens," just as we would say, "This pump delivers 600 gallons per minute." As some pumps require more power than others to make a given delivery of water, so some lamps require more energy (watts) than others to generate the same number of lumens of light. Here we have an expression for the efficiency of a lamp, *i.e.*, "lumens per watt." Neither the lamp rating in lumens nor the "lumens per watt" efficiency can be altered by any change in the shape of the filament or the use of reflectors, or other change in the distribution of the light. The lumen values remain the same, and always express the actual total light flow from the lamp. The "lumen" is a better unit than "mean spherical candlepower," as "mean spherical candlepower" is only an imaginary quantity, and its determination or calculation is a very tedious process. When you have the mean spherical candlepower you cannot apply it in a useful way as you can the lumen. The lumen immediately enables one to determine the degree of illumination given by a lamp. By its definition the lumen "is the amount of light which will illuminate 1 sq. ft. of surface to the intensity of 1 ft. candle." Therefore, knowing the number of lumens, we immediately know the degree of illumination in foot candles on the surface illuminated.

The lumen has been adopted by the engineering societies and lamp manufacturers of the United States and Canada, and with its adoption by the leading British lamp manufacturers its use is becoming more and more widespread throughout the world.

ROTARY CONVERTERS.

A well-illustrated booklet dealing with rotary converters has been issued by Messrs. Siemens Bros. Dynamo Works, Ltd. There is a useful comparison between rotary converter, motor-converter and motor-generator, and the section dealing with the control of voltage on rotary converters deserves special mention. An appendix contains a full list of particulars required for the preparation of a tender for plant of this description.

TOPICAL AND INDUSTRIAL SECTION.

[At the request of many of our readers we have extended the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]

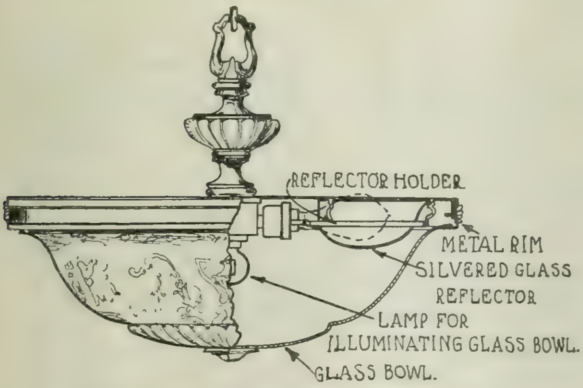
INDIRECT LIGHTING WITH TRANSLUCENT GLASSWARE.

THE accompanying illustrations sent us by the National X-Ray Reflector Company of Chicago refer to two examples of an ingenious modification in indirect lighting units.

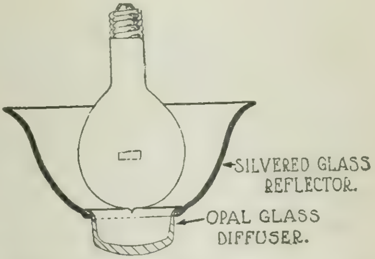
It has sometimes been objected that the opaque bowl, seen immediately under a brightly lit ceiling, is a drawback to indirect lighting, although this effect can be largely mitigated by the use of a pleasing moulded white exterior for the bowl.

In the units shown above a different method of meeting this point is adopted. In both cases the fitting is so designed that while the mirror-glass reflector is used to direct the bulk of the light upward, a small amount is allowed to illuminate a translucent covering bowl, or diffuser at the base of the unit. In this way an effect similiar to semi-indirect lighting is produced but at the same time the essential qualities of indirect lighting are preserved.

We may add that the British Thomson-Houston Co., Ltd., are British agents for these and other X-ray lighting appliances.



X-Ray Indirect Lighting Unit with Luminous Glass Bowl.



A smaller X-Ray Indirect Lighting Unit, also showing the Combination, with a Mirror-glass Reflector and a Luminous Glass Diffuser at the base of the Unit.

THE "METROFLAM" ARC LAMP.

A list recently issued by Messrs. Johnson and Phillips, Ltd., describes the "Metroflam" non-interval magazine flame arc lamp.

Such lamps are stated to give 4000 candles for 500 watts, 3300 candles for 440 watts and 2100 candles for 350 watts, and are recommended for lighting large industrial areas.

IRON AND STEEL INSTITUTE.

At the autumn meeting of the Iron and Steel Institute on September 20th—21st, a number of important and interesting papers were presented.

Among these may be mentioned a comprehensive treatise on "The Eggertz Test for Combined Carbon in Steel," by J. H. Whitely, while Dr. E. B. Wolff discussed in some detail "Failures in Boiler Plates and Stresses in Riveted Joints."

Several investigations related to the heat-treatment of iron and acid open-hearth processes, the briqueting of iron ores, and experiments on shock-tests for the determination of resilience. Other communications dealt with refinements in apparatus for measuring and controlling high temperatures.

PHOTOMICROGRAPHS IN COLOUR.

Lantern slides representing photomicrographs of sections should, in order to give satisfaction, closely resemble the appearance of the section itself. In a note in the *Journal of the Franklin Institute* for August Dr. Kenneth Mees explains that this object can be obtained by making the print in stained gelatine instead of by the usual photographic process. The method of printing is described in detail, and it is stated that the filters required can be selected from the special series of Wratten M filters now available. The photographed negatives are made through these suitable colour filters, and are then dyed in two stains and placed face to face so that a two-colour slide can be obtained.

PERSONAL.

We understand that, on reaching the age-limit this month, Sir Arthur Whitelegge, K.C.B., who has held the position of H.M. Chief Inspector of Factories and Workshops at the Home Office for more than 21 years, retires. During his tenure of office Sir Arthur Whitelegge took a great interest in matters of hygiene, and it was largely owing to his sympathy with the claims of better lighting in factories that the matter was taken up so fully by the Home Office Factory Dept. As a member of the Home Office Departmental Committee on Lighting in Factories and in Workshops, appointed in 1913, Sir Arthur did much to promote the study of this subject.

The Home Secretary has appointed Mr. H. M. Robinson, the Senior Deputy Chief Inspector, as his successor. We are glad to note that Sir Arthur will continue to give his services to the Factory Department in an advisory capacity.

Assets exceed £2,500 000.

Claims paid over £8,500,000.

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General Manager.

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MINISTRY OF MUNITIONS.

CALCIUM CARBIDE ORDER.

An Order issued by the Ministry of Munitions states that from Sept. 24th onwards all calcium carbide in the United Kingdom, except stocks not exceeding half a cwt., will be taken possession of by the Ministry.

During the first seven days of each month, commencing with October, 1917, all persons must furnish to the Controller of Non-Ferrous Materials Supply, AM2/H, Hotel Victoria, Northumberland Avenue, London, W.C.2, monthly returns of :—

(A) All calcium carbide held by them on the last day of the preceding month.

(B) All calcium carbide purchased or sold by them for future delivery and not yet delivered on such last day.

(C) All calcium carbide delivered to them during the preceding month.

No return is required from persons whose total stock of calcium carbide in hand and for future delivery does not exceed half a cwt.

SCIENCE AND TRADE.

Dr. Addison, Minister of Reconstruction, when addressing the annual conference of the Library Association on Oct. 3rd, spoke with special approval of the movement for the creation of additional technical and commercial libraries adapted to the need of each locality. In order to pay for the war the different trades would have to throw their heart and soul into the dissemination of useful and necessary information.

A close working relation between our higher educational organisations and the business community was absolutely essential for our future industrial progress. In any scheme for promoting technical research and information he hoped the libraries would take an important share.

GAS MANTLE LIGHTING CONDITIONS IN TEN CITIES IN THE UNITED STATES.

A technologic paper (No. 99) issued by the Bureau of Standards Washington, and summarised in the Journal of the Franklin Institute for September, gives the results of a careful inspection of about 4500 gas lamps in service in ten of the largest cities in the United States. The condition of mantles, glassware pilot-light and other particulars are noted in order to determine to what extent the consumer benefited through periodical maintenance service.

According to these observations a lamp not on regular maintenance service is likely to be defective 5½ times as often as one which is regularly maintained. Also, on the average, one in three of the lamps on regular maintenance was not in good condition, whereas the defects noted in the lamps not so maintained average more than one for every lamp.

The principal defects in the maintenance systems were also investigated, and one satisfactory system of estimating the expenses for maintenance work, together with a set of unit costs, is presented based on the analysis of the operation of ten gas companies. A suggested table of costs for each type of unit is given.

SAFETY AND GAS LIGHTING.

A recent issue of the *Gas Institute News* refers to the appointment of a Committee on Automatic Gas Shut-offs by the American Gas Institute. The question is being debated whether it is desired to provide an arrangement so that the gas may be automatically shut off in the event of a fire but there is evidently difference of opinion on the subject. A letter has been addressed to Mr. W. H. Merrill, President of the Underwriters Laboratories, Chicago, pointing out that the risk is too insignificant to make such a step desirable.

Quotation is also made from a recent letter from Dr. Stratton, Director of the Bureau of Standards, referring to the value of gas lighting for emergency purposes ; in the event of a fire the gas can be cut off by the police or fire brigade, and interruption of the service rarely occurs until this is done.

THEATRE LIGHTING WITHOUT FOOTLIGHTS.

According to the *Scientific American*, a large theatre in Philadelphia is to be lighted entirely from above, and without footlights. The light will be received from a number of lamps, totalling over 100,000 candle-power, manipulated from a steel bridge above the proscenium arch.

The arrangement is said to enable great flexibility in the direction and distribution of light to be obtained, but it would be interesting to know how the requisite shadow conditions can be secured without any illumination from the front.

ELECTRICITY · ACETYLENE · OIL · GAS

The
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Edited by
LEON GASTER

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EDITORIAL.

The Organisation of Engineering Training.

It will be recalled that on September 27th a preliminary account of the aims of those associated with the movement for the improvement of engineering training was given by Mr. A. E. Berriman and Mr. A. P. M. Fleming, before a gathering of representatives of the Press at the Institute of Journalists on September 27th.*

At the Institution of Civil Engineers on October 25th an important conference on the subject took place, and an account of the proceedings appears in our present number (pp. 265, 266). The meeting was attended by a number of distinguished delegates representing the educational and engineering aspects of the subject, as well as officials of various Government Departments concerned.

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* *Illum. Eng.*, September, 1917, p. 244.

There was practical unanimity regarding the need for some better system of co-ordinating engineering training. The methods pursued by some of the leading engineering firms in the country are recognised to be adequate; but in other cases there is still a tendency to disregard the employer's duty of promoting the welfare of apprentices and ensuring the continuity of education such as would assist them to become intelligent and useful members of the engineering industry, and not merely machines. Again the education provided at our leading Colleges and Engineering Institutions is rightly regarded as second to none. The drawback has been that insufficient use of such institutions has been made, that the education is not developed on a large enough scale, and that the relations between them and the engineering works are not, in general, sufficiently intimate. As an instance Professor Dalby mentioned that when he visited Charlottenburg ten years ago he found about 10,000 students at work, whereas it would be difficult to find 900 students of similar class in this country.

In any steps that are taken to improve the engineering training of the country the utilisation in the fullest manner of the existing educational facilities will no doubt be borne in mind. For example, as suggested by the Rt. Hon. Arthur Dyke Acland, some of the bursaries and scholarships which are to be created by the Government might well be allotted to gifted youths entering the engineering industry.

Yet another weakness in the existing training facilities is that parents are often at a loss to know where to turn for information as to the best method of entering the engineering profession, and on the prospects of a youth with any particular firm. In some instances large premiums have been paid and the results, after several years' apprenticeship, have been very disappointing. In other cases, too, parents have found that after paying for special technical education for their sons, their subsequent prospects are no better, and even worse than if they had entered the works immediately after leaving school. This anomaly needs to be corrected by making technical education an essential part of works training, either by organising classes during working hours on the premises, or by allowing pupils time off from working hours to take courses at the local technical institution.

It was pointed out in the discussion that various universities and educational institutions have appointments boards associated with them, and it would be an advantage if these could be related to the central organisation for the better co-ordination which the promoters of this movement have in view.

All such matters are now to receive consideration at the hands of the Committee, representative of leading engineering institutions, educational associations and universities and technical colleges of university rank, which it was resolved to appoint at the meeting on October 25th. We feel sure that good must come of this close association of educational and engineering interests and the representative character of the committee should ensure the problem being dealt with in a wide and authoritative manner. We would like to add, however, that the success of any scheme evolved for the co-ordination of engineering training depends primarily on the education of public opinion. We therefore welcome the arrangements made by the organisers to maintain contact with the scientific and technical Press, in order that the ground may be prepared through their influence for future action.

Automobile Headlights.

One highly interesting development since the outbreak of war is the use of concentrated filament lamps, in conjunction with suitable polished reflectors, to give what is equivalent to a searchlight-beam.

The use of small electric lamps in motor-car headlights was familiar to this country before the war. More recently the authorities have imposed special regulations regarding the power of such lights, so that conditions are essentially different in this country from those prevailing in the United States. In America, however, the problem of the proper design of motor-car headlights, from the standpoint of traffic, has been actively discussed of late. The Illuminating Engineering Society and the Association of Automobile Engineers have been in co-operation with a view to defining the conditions requisite to provide sufficient illumination of the road-surface without causing excessive glare to pedestrians and approaching vehicles. The problem is a highly complicated one. The various States have endeavoured to deal with the problem by legislation, in some cases limiting the candlepower of the beam, in others prescribing a minimum distance for which the beam must carry. In most cases some attempt is made to limit the beam below the horizontal so as to illuminate the road without dazzling unduly the eyes of approaching drivers. One difficulty, however, is that the beam-conditions which are best adapted to a dark road having relatively little traffic are distinctly different from those which should be adopted in a well-lighted but very busy street. It has been suggested that alternative lighting arrangements should be at the disposal of the driver so that he can apply either method, according to the nature of the traffic, as his judgment finds most suitable.

It is obvious that in very dark surroundings almost any form of headlight involves some degree of glare. There is general recognition that very powerful beams, which can easily be attained, are unduly glaring and in some cases the limit of 1,000 candlepower has been advocated. Yet, on a very dark road, this intensity may give rise to dazzle, even when the attempt is made to keep the rays below the horizontal. It is necessary, therefore, to aim at a compromise between the provision of sufficient road-illumination and the avoidance of glare. From the motorist's standpoint the distribution of light along the road is likewise important. A " spotty " effect, *i.e.*, a bright patch a short distance ahead of the car followed by complete obscurity, is highly inconvenient, and it is also desirable that some subdued light should be allowed to pass to the sides of the road if this can be done without glare.

The design and use of headlights has also been discussed in this country both before and since the war. It was dealt with in a paper before the Illuminating Engineering Society by Dr. Hickman in 1911, at the International Roads Congress in 1913, and has recently received attention from the Royal Automobile Club, the National Physical Laboratory and other bodies.

The discussion on these various points that has been taking place in the United States is full of interest, and the experience gained should have useful applications in this country when normal traffic conditions are resumed after the war.

" Flood-lighting " Projectors.

The flood-lighting projector is a development intermediate between the automobile headlight and the arc-searchlight. In the former we have a relatively diffused beam, though naturally much more concentrated than is used in ordinary lighting units. In the arc-searchlight we have a very limited beam with a dispersion, in some cases, of 2° or even less.

The flood-lighting unit is a development which has made great progress in the United States since the outbreak of war. In this country it is little known as yet, except for certain specific purposes. These units employ a very concentrated filament lamp, with a suitable parabolic polished reflector. In the smaller units the dispersion is stated to be as little as 10° but provision is made to spread the beam, if desired, by putting the lamp slightly out of focus. In the larger units 16°—20° may be a more usual dispersion ; by special diffusing cover-glasses this can be increased to 40°, when a wider beam is required.

The unit is thus equivalent to a searchlight with an incandescent filament of small dimensions as the source. From the data given in an article on the subject in the present issue (see pp. 259—263) it appears that with a 500-watt lamp a maximum candlepower exceeding 300,000 can be attained. In this case, however, it is clearly inadvisable to rate the unit in terms of maximum candlepower alone. The total flux of light in the beam is also of importance. According to the results quoted a projector using a 400-watt lamp, which gives 5,920 lumens, enables a beam to be secured with a total output of 2,940 lumens. The efficiency of the whole apparatus is thus about 40 per cent.

Such units might be expected to have important applications for work in which searchlights of moderate power are useful, and the ease with which it can be transported and switched on and off is an important consideration.

While flood-lighting units have been largely employed for spectacular lighting (*e.g.*, for the illumination of the National Capitol at Washington) before the war, they appear to be now proving useful for providing safety-lighting around arsenals, important factories, bridges, etc. With a relatively low consumption (estimated at 0·01—0·02 watt per square foot of area illuminated) adjacent areas can be flooded with light so that the presence of any unauthorised person can be at once detected by those on duty. This appears to be one more practical illustration of the truth of the saying that " Good lighting is the best policeman."

The special circumstances prevailing in the belligerent countries in Europe are not favourable to the general employment of these units at the present time. After the war, however, they may prove to have many important applications, and for spectacular lighting, for illuminating signs, façades, etc., they will often prove more economical than the customary methods of using a multitude of small exposed lamps. We recall that in the first volume of this journal we pointed out the desirability of such methods in referring to the lighting of the Franco British Exhibition, and the matter has been frequently discussed in subsequent issues. It seems likely that concealed lighting methods will play a more important part in the exterior lighting of the future.

LEON GASTER.

SOME NOTES ON ELECTRIC HEADLIGHTS AND FLOOD-LIGHTING UNITS.

BY AN ENGINEERING CORRESPONDENT.

THE applications of concentrated filament electric lamps in suitable reflectors to produce a relatively narrow and powerful beam of light has been receiving much attention in the United States, and we have given several examples of notable "flood-lighting" installations in recent issues.

A cognate matter is the problem of the design of automobile headlights which has been the subject of study on the part of the American Illuminating Engineering Society and the Society of Automobile Engineers (U.S.A.). Some recent discussions on this subject were summarised in this journal a short time ago,* and we notice that several useful supplementary papers on the subject have since appeared

AUTOMOBILE HEADLIGHTS.

The problem resolves itself into a compromise between the requirements of illuminating the roadway ahead and eliminating, so far as possible, the inconvenience of glare. These two objects are, in a measure, inconsistent, and we can only make the best balance possible in the circumstances. On a dark road even a light of moderate brilliancy is apt to dazzle an approaching pedestrian. And though it may be so designed that the beam does not actually strike into his eyes, the mere fact of portions of the roadway and surrounding objects being relatively brightly lighted may prejudice his powers of vision. On the other hand the responsibility of avoiding accidents rests mainly with the more mobile and faster unit, *i.e.*, the motor-car, and it is chiefly important that drivers should see clearly any objects on the roadway, and that their headlights should not be mutually inconvenient.

It is evident that the ideal form of headlight will depend to some extent on the nature of the road. H. P. Gage, in a recent analysis of the problem,* divides roads into three categories: (a) Ordinary country roads, having relatively rough surfaces on which few other cars are encountered and the motorist has little to fear from glare through opposing headlights. Such roads are probably relatively rough and the driver must have enough light to look out for ruts and surface imperfections, but he has few moving objects to avoid.

From the motorist's standpoint this is a fairly easy problem; (b) macadamised city roads, or what are termed "State roads," where there are many vehicles and considerable difficulty is apt to be caused by glare. More attention should, therefore, be concentrated on avoidance of dazzle, and there is less necessity for a powerful headlight to illuminate the road. Finally we have (c), the city road, which receives ample artificial illumination, and where, therefore, the headlight has not much to do in the way of illuminating the road surface, and is of value chiefly as an indicator of the position of a vehicle.

The steps that have been taken to avoid glare have been chiefly in the direction of spreading the rays and bending them downwards. The effect of various types of beam is shown by the author by a series of photographs. It is recognised as prejudicial both to the driver and to approaching vehicles and pedestrians to have a headlight which concentrates the light in a very narrow region producing a spot of light a short distance ahead and then complete darkness. In these circumstances a driver cannot see the outlines of an approaching car until it is almost on him. A more recent refinement is the design of a type of headlight which excludes light from the right hand upper corner of the field. In this way the risk of dazzling drivers approaching on the right is minimised.

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* *Illum. Eng.*, July, 1917, p. 183.

* *Trans. Ill. Eng. Soc.* (*U.S.A.*), June, 11th, 1917, p. 179; *Gen. Elec. Review* (*U.S.A.*), Sept., 1917.

The author suggests that in general severe glare will not occur if the candlepower of the beam does not exceed 1,000 ; on the other hand, headlights producing 20,000—60,000 candles, which can easily be produced, are too dazzling.

An interesting device described by the writer is an appliance for testing glare. The headlight is mounted among a series of illuminated letters, and if the latter cannot be seen the light is considered glaring.

The problem is also surveyed in an article by E. J. Edwards in the *Electrical Review and Western Electrician.** Although legislation has been introduced in many States, chiefly in the direction of limiting the power of the beam, or the length of road illuminated ahead, the results are not entirely satisfactory. While 1,000 candles is, no doubt, a satisfactory upper limit in the well-lighted streets in a city, on a country road even 100 or 200 candles may be glaring. The author illustrates this point by a diagram showing the degree of interference with vision, and the approach to the condition of totally blinding glare, with headlights of various powers. From this it appears that glare exists with relatively weak lamps below 1,000 candles, that after passing 5,000—10,000 candles we are already approaching the dazzle-limit ; while from 40,000 candles onwards we are so near the limiting dazzle-point that increase in brilliancy further makes very little difference. Existing laws also prescribe limiting values for the candlepower above the horizontal. The chief considerations in the author's opinion, are to produce good illumination on the road immediately in front of the vehicle, to practically eliminate all upward light, and to limit the angle for the high intensities below the horizontal sufficiently to provide a factor of safety as regards changing loads in the machine and varying curvatures on the road surface.

An ideal system would give a good illumination on the road for up to 75 feet ahead and of a width sufficient to cover the roadway, say for 15—20 feet, while reducing light in the upward angles to the absolute practicable limit. The upper limit of the high-intensity beam should be depressed about two degrees below the horizontal. Even these conditions have disadvantages, and it is open to consideration whether alternative lighting methods should not be permissible, to be adopted, according to the judgment of the motorist, as the nature of the road suggests.

RAILWAY SIGNAL LIGHTS.

Some particulars of the use of electric lamps for railway signals were given by A. H. Rudd and others at a meeting of the Illuminating Engineering Society.* It was stated that on some railways lights sufficiently powerful to be seen in daylight at a distance of 500—600 feet were in use, while Mr. C. H. Morison, referring to experience on the Pennsylvania railway, said that with 37-watt lamps, giving 7,000 candles within two degrees from the centre of the beam, signals could be rendered visible at a distance of 7,000 feet in full sunlight.

FLOOD-LIGHTING PROJECTORS.

Highly concentrated filaments combined with polished parabolic reflectors have likewise been developed as searchlights and for signalling outfits. L. C. Porter† mentions a 12-candlepower lamp with a 10-inch Mangin reflector giving signals which could be read, on a clear day, as much as 50 miles away. Such units are recommended for motor-boats and coast patrols.

Type of lamp.	Dimensions of filament (mm.).		Max. beam candle-power.
	Diam.	Length.	
6 volt 108 watt	2·0	6·5	462,000
32 .. 100 ..	5·0	5·0	223,000
110 .. 100 ..	6·5	6·5	142,000
110 ,, 100 ..	8·0	8·0	32,600
110 .. 100 ..	25·0	0·5	12,700
110 .. 100 ..	30·0	68·0	3,800

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* *Electrical Review and Western Electrician.* Sept. 29th, 1917, p. 546.

* *Trans. Ill. Eng. Soc.* (*U.S.A.*), Aug. 30th, 1917, p. 277.

† *Trans. Ill. Eng. Soc.* (*U.S.A.*), June 11th, 1917, p. 191.

The candlepower attainable from a searchlight is naturally largely dependent upon reducing the incandescent surface of the filament to small dimensions. To illustrate the importance of this item Porter gives the results of a series of tests on a reflector fitted with filaments of varying size, in the preceding table.

An equally important point is the correct focusing of the filament, in some cases a dispersion of the beam being deliberately produced by removing the lamp further from the focal point. In this way a range of dispersion within wide limits can be secured. This is illustrated by the illumination values obtained from a searchlight with the filament in different positions. In a case specified 22 ft.-candles was secured axially at a distance of 100 feet (equivalent to 220,000 candles). By moving the filament back $\frac{1}{4}$-inch behind the focus the maximum illumination was reduced to about one-tenth.

Some useful data on floodlighting units is provided by J. L. Stair and K. W. Mackall in two articles in the *Electric Journal*.* The 500-watt unit can be adjusted to give 10° dispersion with the filament accurately focused, but provision is made to spread the beam over 16°—18° if necessary. In the case of the 1,000-watt unit, the limit of dispersion is greater, namely, 16°—18°. The data are worked out for a 400-watt 115-volt lamp, yielding 5,920 lumens. Of the light furnished by such a unit using a 16-inch mirror with a 2·75-inch focus, 68 per cent. strikes the reflector, and of this 64 per cent. is reflected. A further 85—92 per cent. will be transmitted by an ordinary clear-glass cover. The lumens utilised in the beam are thus :—

$5920 \times 0{\cdot}68 \times 0{\cdot}64 \times 0{\cdot}92 = 2400$ lumens approximately. The efficiency of the arrangement is thus about 40 per cent.

A practical case, in which the beam is used to illuminate an inclined surface 2,300 feet distance, is worked out. The diameters of the ellipse limiting the beam where it impinges on the surface are 70 feet and 61 feet respectively. The area of the ellipse is thus approximately 3345 square feet and the illumination is $2400/3345 = 0{\cdot}7$ foot-candle approximately.

With the beam put out of focus so as to get a wider dispersion the area of the ellipse may be increased to 11,050 square feet, and the illumination will then be about 0·2 foot-candle.

In calculating the distribution of light illumination in the beam it is necessary to work from the polar curve, dividing by the square of the distance from the point concerned, on the inverse square principle, which, for moderate distances, applies sufficiently closely.

A 500-watt 115-volt lamp, in a 2·75-inch focus 16-inch diameter mirror, gives a maximum beam candlepower of about 330,000.

Special cover-lenses are also provided for particular light-distributions. For example, the glass may be provided with minute prisms to give a 40-degree dispersion, or may consist of a series of plano-concave lenses, ground vertically to spread the light in a horizontal plane only.

It is stated that when a general illumination is required near important factories and arsenals or in tunnels, &c., merely in order to facilitate supervision, the consumption necessary is only 0·01—0·02 watt per square foot of area to be lighted. A unit mounted at a height of 50 feet and throwing its maximum beam at an angle of 30 degrees below the horizontal will illuminate an area of 40 feet wide and 80 feet long. For night-construction work a higher order of illumination is naturally necessary, 0·1—0·25 watt per square foot being allowed. Cases of spectacular illumination (such as the illumination of the National Capitol and the Statue of Liberty in New York Harbour) may require special arrangements.

Apart from such spectacular displays, floodlighting is being widely used in the States for providing a protective safety-illumination round premises of importance by night. For example, a factory may mount such units at intervals on the roof so as to flood all the adjacent streets with light, and enable a watchman to detect the presence of any loitering intruder. The same practice has been applied to tunnels and subways by night and on bridges. A case is mentioned of a bridge equipped with five 200-watt units on each side, mounted eight feet above the surface of the water. The area so lighted was, roughly, 150 feet wide and 100 feet long (the breadth of the river). It enabled the guards to see at once any craft approaching the bridge whilst themselves in darkness. Such "searchlight illumination" is naturally productive of glare so far as concerns the area illuminated. A person emerging into the rays would presumably be dazzled. As, however, the illumination is specifically contrived to prevent the presence of unauthorised persons in such areas, this is not necessarily a drawback. The conditions are eminently favourable to vision on the part of the guards or observers who can see without being seen, and the presumption is that persons straying into the light are not intended to observe much. On the other hand the method would have to be used with discretion in cases where people are constantly passing on their ordinary duties, and especially where there is any amount of fast traffic.

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* *Electric Journal*, Aug., 1917, pp. 296—304.

Photometric Tests of Floodlighting Projectors.

The method of testing the candlepower of floodlighting units also deserves mention. Some particulars are given by S. L. E. Rose in the *General Electric Review* (U.S.A.), and while fuller details on some points would be useful the general method of testing is explained. Experiments were made with a portable illumination photometer mounted on a tripod, the current through the lamp being adjusted with ammeter and rheostat. Tests are conveniently made at a distance of 50 to 100 feet, and in these circumstances, apparently, the inverse square law may be assumed. In a searchlight or floodlight unit all the rays in the beam come from the mirror. The application of the law in the case of automobile headlights would appear less certain, since in this case a lens is utilised, and we have, therefore, a combination of the dispersed beam from the reflector and a more or less concentrated beam from the filament operating direct through the lens. While the long distance of test usually makes it necessary to work out of doors, it is preferable to carry out the tests in a long room. This can be done if appropriate screens are used to eliminate reflections from walls and stray light. The unit to be tested may be mounted on an adjustable table and rotated while the photometer is kept still; or the unit may be kept stationary and the photometer moved across the beam. The polar curve can be conveniently plotted at intervals of one degree or less, such small intervals being desirable in view of the restricted angle of emission. Such a test readily gives the maximum candlepower and the total flux of light in lumens could also be deduced therefrom. The author mentions, however, that measurements of total flux, and comparisons of this with the corresponding flux of the bare lamp, can also be made in the Ulbricht globe—an interesting statement in view of the highly concentrated nature of the beam and the question whether the Ulbricht globe can be accurately applied in such extreme cases as this. From such measurements in the globe the efficiency of the apparatus could be readily deduced. A 2,400-watt unit yielded about 2,600 lumens in the beam—a value not far removed from that given by other observers for a similar unit,* mentioned earlier in this article. Tables are also presented giving the "lumen-constants" for successive zones and enabling the lumens in each area to be deduced.

ECONOMY IN LIGHTING IN THE UNITED STATES.

While hitherto the necessity for lighting economies has not been pressing in the United States, the problem is now beginning to attract attention. It was recently stated that the very high order of "display illumination," employed on the "Great White Way" and other main thoroughfares is to undergo some diminution.

In cases where light has been used in abundance for spectacular purposes, there is doubtless justification for economy. But the provision of proper lighting from the safety standpoint is regarded as highly important.

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* *General Electric Review* (*U.S.A.*), Sept., 1917, p. 743.

Obituary.

WILLIAM DUDDELL.

Born 1872—Died 1917.

We record with great regret the death of Mr. W. Duddell, which occurred on Sunday, November 4th. He had been in failing health throughout the past year and his sudden death, at the early age of 45 years, removes one of the most brilliant and original investigators in this country.

After serving his apprenticeship with Messrs. Davey Paxman and Co., Mr. Duddell entered the City and Guilds Central Technical College, under Professor Ayrton, in 1893. Here he remained for a number of years, being awarded several exhibitions and scholarships, and soon gave evidence of the skill in experimental work which he afterwards applied in such varied directions. Some of his earliest work dealt with the theory of the alternating current arc, and it was in the course of these experiments that he developed the oscillograph associated with his name, which has since proved such a potent instrument for the study of alternating current phenomena. His paper before the Institution of Electrical Engineers on "Rapid Variations in Current through the Direct Current Arc" was remarkable for its analysis of the musical arc as a source of high-frequency currents, which has been made use of in wireless telegraphy.

Mr. Duddell, while perhaps pre-eminent in the design of new electrical measuring instruments, made many contributions to the study of telephony, wireless telegraphy and other fields of work. His scientific interests were exceptionally wide, and his gift of lucid exposition and skill in arranging demonstrations and experiments made him an excellent lecturer. At the early age of 40 he became President of the Institution of Electrical Engineers, holding office for two successive years. He was also President of the Röntgen Society and a Vice-President of the Physical Society. He was elected a Fellow of the Royal Society in 1907 and was awarded the Hughes Medal in 1912.

Mr. Duddell acted as Honorary Secretary of the International Conference on Electrical Units and Standards held in London in 1908. He was also one of the British delegates to the International Electrotechnical Congress held in Berlin in 1913, and to the International Photometric Commission held on the same occasion, when the resolution in favour of the formation of an International Commission on Illumination was passed. Mr. Duddell became President of the National Illumination Commission in this country following the death of Mr. Edward Allen. As President of the Institution of Electrical Engineers he became *ex officio* a Vice-President and Member of Council of the Illuminating Engineering Society, and he took a keen interest in lighting matters.

After the outbreak of war he assumed important duties as a member of the Advisory Council for the Promotion of Scientific and Industrial Research, and of the Board of Inventions to the Admiralty. Recently he was created a Commander of the Order of the British Empire.

Although Mr. Duddell's exceptional gifts brought him many honours in the scientific world at an early age he retained the unassuming spirit characteristic of the true scientist and natural to his courteous and kindly disposition. The vein of light humour which he combined with his earnestness in scientific work made him a delightful companion.

TECHNICAL EDUCATION AND THE LEATHER INDUSTRY.

An address delivered by Professor Michael Sadler, Vice-Chancellor of Leeds University, to the members of the United Tanners' Federation on July 1st, contains many wise observations on technical education, which apply broadly to all industries.

Professor Sadler pointed out that the existing defects have deep roots. Technical education, in order to be effective, must be preceded by a good general education. The position of science in secondary education is still unsatisfactory. In all State-aided secondary schools science is taught, but in the public schools boys learn very little science, and their interest in the subject is blunted at the very time when it ought to be stimulated. This matter is now receiving attention from a Government Committee.

The neglect of science in secondary education is of vital importance to such industries as the leather trade, which should use their influence to secure improvement, not only in the time allotted to science, but in the methods by which the scientific spirit can be instilled and fostered.

Professor Sadler alluded to the part played by the Universities, which are in a favourable position to unite the scientific investigator and the practical worker. He urged particularly that the United Tanners' Federation should establish a research committee on which these two necessary elements should be combined; and, having done so, that they should approach the Department of Scientific and Industrial Research for their assistance and support.

Finally Professor Sadler outlined the system of education necessary for the worker entering the leather industry, the expert chemist, and for youths destined for the higher positions of responsibility. Every boy should attend day-time classes and should be regarded "not as a tool to be sharpened, but as a fellow citizen to be developed and educated." For those destined for positions of responsibility a combination of study at the University and access to works in the vacations should be encouraged.

A NEW TRIANGULATION SIGNAL LAMP.

A contribution by Mr. E. G. Fischer to *Science* refers to the special lamps required in geodetic surveys over large areas, the distance between points studied being usually from 10 to 100 miles, or even more. In the daytime use is made of the reflection of sunlight from a mirror placed accurately over the point to be indicated, while at night specially designed acetylene lamps have hitherto been used. Distances of the order mentioned can only be penetrated under favourable atmospheric conditions, and many days and nights during the season are lost owing to fog and mist. It is therefore desirable to attain a maximum brightness in the source of light used.

Experiments have recently been made by the United States Geodetic Survey on electric light. One of the chief difficulties is the supply of current from a source of small weight and bulk. Electrical generators are too heavy for transport and storage batteries are also inconvenient in this respect when great distances have to be covered. It appears, however, that the problem can be solved by using a battery of dry cells, which can be readily subdivided, and the weight distributed when making ascents. An electric lamp with a concentrated filament has been specially designed for this work. This is mounted in an automobile headlight. The apparatus also includes an ammeter, rheostat and switch. When packed in a strong case the weight is approximately 23½ lbs. It is estimated that the new arrangement will increase the number of nights during which observations can be taken by 25 per cent.

THE ORGANISATION OF ENGINEERING TRAINING.

It will be recalled that in our last issue reference was made to the forthcoming conference on Engineering Training to take place at the Institution of Civil Engineers, on October 25th, a preliminary announcement of which was made to a representative Press gathering at the Institute of Journalists on September 27th.

The meeting was opened at 3.30 p.m. by Sir Maurice Fitzmaurice, President of the Institution of Civil Engineers, a large and distinguished gathering being present.

Mr. A. P. M. Fleming read a letter from Mr. H. A. L. Fisher, Minister of Education, regretting that an important engagement prevented his being present and expressing his interest in the proceedings. The Chairman then called upon Mr. A. E. Berriman to open the discussion by a brief outline of the proposed Central Organisation for improvement in and better co-ordination of Engineering Training (information on which was also conveyed in a printed Memorandum placed in the hands of the audience).

Mr. Berriman explained that the proposal originated in an informal conference of engineers and educationists, which held several meetings at the Board of Education in the early months of 1917. The view was expressed that it would be preferable to establish the proposed organisation on an independent footing, but with the co-operation of the Board of Education and other educational bodies, and Mr. Fisher had concurred in this view. Ultimately the Council of the Institution of Civil Engineers was requested to lend their theatre for a general meeting, at which delegates representing the leading engineering institutions, educational authorities, and Government departments concerned could confer.

The three chief objects on which the proposed Central Organisation might usefully concentrate attention are summarised as follows :—

(1) The co-ordination of engineering training, including the fostering of apprenticeship as a National Institution, and the consideration of means by which the works period of an engineering pupillage may be increased in efficiency, and a wider appreciation secured for the value in industry of education of university rank.

(2) The maintenance of a Central Bureau, where parents and educationists can obtain accurate and comprehensive information relating to the engineering industry, and the proper course to pursue on behalf of boys who are desirous of making engineering their profession.

(3) The promotion of scholarships, or other equivalent means by which the best talent may be enabled to rise to the proper level under the stimulus of educational opportunity.

In the discussion that ensued a considerable number of delegates, representative both of engineering and educational aspects, took part. A general recognition was expressed that some measure of the kind suggested was necessary to place engineering education on a proper basis and enable the engineering industry of the country to maintain its pre-eminent position. On the educational side it was pointed out that this was the first opportunity provided for the public discussion of these problems between those concerned with school and university education and with the engineering industry respectively. It would be very beneficial to have a central organisation to promote constant interchange of views.

A point that was strongly emphasised by Sir John Wolfe Barry and others was the changing outlook of employers towards apprenticeship. The leading employers now recognised that, in their own interests, as well as that of apprentices, it was necessary to pay careful supervision in their training ; to look to their future value, and not merely at the immediate service that youths entering engineering shops could render. In particular the wages of apprentices should be on such a scale that it paid a boy to be properly trained; it was hopeless to expect parents to encourage their sons to undergo a long preliminary training if, on leaving school, they could earn more by undertaking immediately remunerative menial work, but without future prospects of improvement. Yet another point on which there was general agreement was the vital necessity of providing opportunities for technical education during working hours, and not at the end of the day's work when a boy was too tired to profit by classes. In this connection the Rt. Hon. Arthur Dyke Acland referred to the steps which the Government had in view for providing additional scholarships and bursaries, and suggested that the projected committee should consider how these facilities could best be utilised in connection with their reforms in education engineering training.

An important matter from the engineering standpoint, to which several speakers referred, was the allocation of expenditure on scholarships and education. Ultimately, it was suggested, the cost of education should be born mainly by the State, and it was desirable to use as fully as possible the existing facilities. Professor Dalby pointed out that the education provided at leading engineering colleges in this country was as good as that obtainable anywhere, but insufficient use was made of it. Ten years ago he had been informed that there were 10,000 students over 18 years of age taking advanced classes in engineering at Charlottenburg, where, as in England, it would be difficult to find more than 900 students of similar class. Early specialisation was not desirable. The important thing was to build up a pedestal of general engineering and scientific knowledge, on which any special studies could be based. This aspect was also touched on by Dr. Hadow, who remarked that a form of education was needed which would turn out not only good engineers but good citizens; besides vocational study, there should be opportunities for general cultivation. Sir S. Selbey Brigge (Board of Education) welcomed the scheme on behalf of his Department, and emphasised the value of representative engineering bodies with whom educationists could confer. The information bureau should prove useful, but its functions should resemble those of Appointments Boards, and it should not degenerate into an employment agency.

The following Resolution was proposed by Sir John Wolfe-Barry (Past-President of the Institution of Civil Engineers), seconded by Dr. W. H. Hadow (Principal of Armstrong College, Newcastle-on-Tyne), and supported by the Rt. Hon. Arthur Dyke Acland:—

"That this meeting of engineers and educationists is of the opinion that a need exists for improvement in and better co-ordination of engineering training, and considers that some form of central organisation is a desirable means to this end. It is therefore resolved that a representative committee, with powers to add to their numbers, be appointed to initiate means that will give effect to this principle of a central organisation, and that the first members shall be representative of the following bodies:—

Institution of Civil Engineers, Institution of Electrical Engineers, Institution of Gas Engineers, Institution of Mechanical Engineers, Institution of Mining Engineers, Institution of Mining and Metallurgy, Institute of Naval Architects, The Technical Committee of the Motor Industry, Iron and Steel Institute, Federation of British Industries, Liverpool Engineering Society, British Engineers' Association, South Wales Institute of Engineers, Institution of Civil Engineers in Ireland, Institute of Metals, Institution of County and Municipal Engineers, Junior Institution of Engineers, North-East Coast Institution of Engineers and Shipbuilders, Institution of Engineers and Shipbuilders in Scotland, British Electrical and Allied Manufacturers' Association, Joint Committee of the Aeronautical Society and Society of British Aircraft Constructors, The Board of Education, The Headmasters' Conference, The Incorporated Association of Headmasters, The Association of Technical Institutes, The Universities and Technical Colleges of University rank.

The Resolution was carried unanimously and a vote of thanks to the Chairman concluded the proceedings.

It is announced that pending further developments communications may be sent to Mr. A. P. M. Fleming (British Westinghouse Electric and Manufacturing Co., Ltd., Trafford Park, Manchester), or Mr. A. E. Berriman (Chief Engineer, Daimler Co., Coventry), who were appointed to act as Hon. Organisers of the meeting.

SHORT NOTES ON ILLUMINATING ENGINEERING.

COLOUR SCHEMES AND SHELL SHOCK.

Much interest is being taken in the experiments of Mr. H. Kemp Prosser, the well-known artist, on the effect of colours on victims of shell shock.

These experiments are being undertaken at the McCaul Hospital in Welbeck Street. It has long been known that colours have an appreciable influence on the mind and nervous system. Red, for example, has been regarded as having a stimulating or even exciting effect, while blues and greens are sedative. It seems reasonable to suppose that in the case of men whose minds are disturbed or whose nerves are shattered these effects would be especially marked.

Accordingly the colour scheme of the wards occupied by such patients is to be carefully designed with a view to producing a harmonious but cheerful effect. The colours will be those associated with spring, and dreary autumn tints will be avoided. The walls may be yellow, the ceiling a firmament blue and the wood work green, and other appropriate tints will be given to the blinds and bed-covering. In addition, liberal use will be made of flowers of selected hues, such as delphiniums, carnations, and even mauve orchids specially imported from Salonica.

Under Mr. Prosser's supervision the production of pleasing and harmonious effects will be aimed at, and it is thought that these bright conditions will be much more beneficial to the patients than the rather drab and dreary surroundings of the average hospital ward.

THE PERILS OF UNLIGHTED STREETS

We notice in the *Gas Journal* a reference to an incident which strikingly illustrates the growing recognition of the danger of inadeqately lighted streets. At the Newton-le-Willows District Council on September 18th reference was made to a resolution passed at a meeting of the representatives of the engineering works of Earlesdown and Newton. A letter had been sent to the local police authorities saying that the men would refuse to go to work at nights unless some light was allowed in the streets owing to the many serious accidents which occurred in the excessive darkness of last winter. The Lighting Committee of the Council passed a resolution authorising the Gas Engineer to light a hundred street lamps with the tops darkened, and to let the police take proceedings if not satisfied.

THE COMBINATION OF NEON AND MERCURY TUBES FOR LIGHTING.

In a recent patent M. Georges Claude proposes the use of mercury tubes, in conjunction with neon tubes, to produce an approximately white light. A few drops of mercury are inserted into a neon tube and an alternating current is passed through until the mercury is volatilised and its greenish light completely replaces the red neon radiations. This corrector tube is then used in conjunction with an adjacent neon tube so that the addition of their radiations produces the desired white light. For this purpose the radiations must be suitably proportioned; the red and green tubes may have the same diameter and current, but the latter should be twice as long as the former.

SCHOOLROOM LIGHTING.

A correspondent sends us a note on the above subject, which appeared in *Building*, a Sydney journal. We are glad to note this evidence of interest in lighting problems in Australia. The author remarks that while many schools, states, and cities make it compulsory for the eyesight of children to be examined, relatively little effort has been made to remedy one source of such trouble—inadequate lighting of the schoolrooms. "How often," he says, "do we find beautifully designed school structures splendidly equipped, but with abominable means of illumination." There is no excuse for this condition since the advent of the professional illuminating engineer, and the many satisfactory devices and appliances now available, together with the skilled application of the same, to any problem of school lighting."

Reference is made to several main points in the lighting of classrooms, and it is recalled that tests in Philadelphia, under the direction of the Board of Education in that city, suggested that an intensity of 2·25—2·5 foot-candles, with semi-indirect lighting, gave very good results.

It is suggested that in the future school-lighting will be regulated by law, just as several states are now introducing legislation on factory lighting. In the future the services of an illuminating expert should be secured in connection with the design of school-buildings. The cost of his services will be more than saved in the reduced cost of the installation, but the protection to the pupils' eyes should be the first consideration.

POPULAR LECTURES ON HOME LIGHTING.

We understand that a popular lecture has been prepared by the Illuminating Engineering Society in the United States, entitled "How shall I Light My Home?" The lecture deals fully with general principles of domestic lighting, and the problems involved in the illumination of specific rooms, such as halls, libraries, dining rooms, bedrooms, etc., are also discussed. Descriptive lantern slides are available. Like the previous popular lecture on Store Lighting, this lecture is applicable alike to gas and electric lighting. Further particulars are obtainable from the General Offices of the Society, 29, West 39th Street, New York.

GLASS RESEARCH.

The *Proceedings of the Institute of Chemistry* (Part III.) contain some reference to the important work recently carried out on Glass Research. A quotation is made from the statement of the Minister of Munitions in the House of Commons on June 28th of the present year, acknowledging the assistance of scientific men in connection with optical apparatus required for gun sights, aeroplane photography, and many other special purposes. Previous to the war, this country could obtain from British sources only about 10 per cent. of the optical glass the country required. A whole group of industries connected with the glass trade has now been placed on a secure foundation. A process whereby great quantities of potash may be obtained has been discovered, and is being developed with the assistance of the Ministry. We should now be able to provide every ounce of potash that the glass trade requires, as well as very largely to meet the needs of agriculture.

The Glass Research Committee have added to their list, among other various and optical glasses a glass designed to hold tungsten wires sealed into it, required for the manufacture of electric incandescent lamps.

LIGHTING DIFFICULTIES IN DENMARK.

The growing need for economising coal supplies has led most of the belligerent countries to consider the matter of local lighting economies, and we note that in Germany rigid restrictions have already been made in some districts. According to the *Gas Journal*, the position in Denmark is becoming still more acute.

Denmark is specially dependent on imported supplies of coal; at a recent public meeting Mr. Rode, the Minister of the Interior, pointed out that the future was very uncertain, especially in regard to industry, gas works, and electrical supply companies in large towns.

But there was also a prospect of the shortage of other materials for illumination. It was not yet known whether supplies of petroleum could be obtained, and they had therefore endeavoured to provide lighting during the winter from train-oil spirit and calcium carbide. It was hoped that it might be possible to import carbide from carbide-producing countries. Tallow candles, train-oil lamps, and other means of lighting used in the far-distant times of the past would, perhaps, become Denmark's only method of lighting in the near future. Great privations were unavoidable, and it was only by the utmost co-operation and mutual support that Denmark would be able to fight through the fourth year of the war.

FLOODLIGHTING FOR FLOWER-BEDS.

According to the *Electrical Review and Western Electrician*, a novel use is being made of floodlights in Joplin (Mo.), where a company has applied the method to the illumination by night of the flower-beds in front of their offices. This is said to be the first time that floodlights have been used for this particular purpose, but we recall that in referring to the Franco-British Exhibition in the first volume of this journal, as far back as 1908, we advocated concealed lighting for the flower-beds in gardens and exhibitions by night.

LIABILITY FOR FAILURE TO LIGHT STREET LAMPS.

We have several times quoted cases in which the question of liability for compensation due for accidents caused by insufficient street-lighting arose. We notice, in a recent issue of the *Electrical World*, a reference to a case in South Carolina which is of interest in this connection.

In an action against a city to recover for personal injuries received in a collision caused by the defective condition of a street, where the city, which owned the electric light plant, had failed on the night of the accident to light a lamp at the crossing of two much-travelled streets, the jury might reasonably infer that city had been negligent. The Supreme Court of South Carolina held (93 S.E. 180) that the negligent failure constitutes a "defect in the street" and a "mismanagement" of the lamp, so as to render the city liable to one who suffers personal injuries in a collision between his bicycle and an automobile, caused by such neglect.

INCREASED USE OF ELECTRIC INCANDESCENT LAMPS FOR STREET LIGHTING IN THE UNITED STATES.

We understand that since the war electric incandescent lamps, especially the gas-filled variety, have been used in greatly increased numbers for street lighting in the United States. The returns for the year 1916 show an eightfold increase as compared with 1913.

RULED GLASSES FOR THE DIMINUTION OF LIGHT IN PHOTOMETRY.

In a recent article in this journal,* it was remarked that there are few satisfactory methods of dimming incident light in photometry. The use of neutral glasses is one of the most convenient devices, but in general it has two drawbacks—(1) that the glass is not exactly neutral, and (2) that it is rather difficult to obtain a progressive diminution in light by this method.

It is therefore of interest to observe that in a recent issue of the *Zeitschrift für Instrumentenkunde* Dr. H. Krüss proposes to solve this problem by the use of clear glasses on which opaque lines are ruled. This idea has been suggested by Ives in the United States, who also contrived by rotating two ruled glasses with respect to each other to vary the absorbtion progressively. If such lines are ruled closely, *e.g.*, about 100 to the inch, no appreciable shadow will be cast on the photometric field. Krüss now proposes to use two ruled screens of this kind, but to superimpose one in front of the other and alter their lateral position by means of a micrometer screw. In this way the amount of absorbtion can be progressively increased, becoming zero when the dark lines in one screen are superimposed over the clear spaces in the other. The micrometer screw-head can be calibrated in terms of the absorbtion produced.

The apparatus can be conveniently attached to a Lummer Brodhun photometer, and as the observer sees not the white screen itself but the prism surfaces illuminated thereby, he is not conscious of any inconvenient shadows in the field of view.

POLARISATION FLICKER PHOTOMETERS.

Dr. S. Maisel, who is associated with the Electrotechnical Section of the Russian Technical Society, and is the Editor of *Electritchestvo*, has sent us a copy of a paper presented by him in March 1907, describing a form of polarisation photometer, similar in principle to that recently mentioned by Dr. Ives in the *Philosophical Magazine* (April, 1917), and referred to in our May issue. A description of Dr. Maisel's instrument also appeared in the Journal of the Russian Physical Society for 1907. A specimen instrument was constructed abroad previous to the war, but it is hoped that ultimately it will be made in Russia. In the final form several (either two or three) fields of view are presented, in which the flicker-phenomena are shifted in phase by 180°. Preliminary experiments have shown that this greatly increased the sensitiveness of the instrument.

Another item of news received from Dr. Maisel is that the Electrotechnical Section of the Russian Technical Society has now formed a Standing Commission on Illumination, in which members of various scientific and technical societies will take part. This is a gratifying development of illuminating engineering in Russia, which will be followed with close interest.

THE NOMENCLATURE OF RADIATION AND ILLUMINATION.

A recent paper on this subject by H. E. Ives in the *Astrophysical Journal* makes a number of detailed suggestions for the more complete description of terms used in radiation. Tables are presented showing the relation between radiation and illumination, and proposing terms to replace a number commonly used in text-books to denote the same quantity.

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* *Illum. Eng.*, July, 1917, pp. 190—192.

THE MAINTENANCE OF RESIDENCE GAS LAMPS.

In the *Transactions of the Illuminating Engineering Society* (*U.S.A.*), dated July 20th, a paper by H. H. Newman strongly advocates the undertaking of free maintenance by gas companies. There are three chief systems of maintenance in use in the United States, the "consumer request" plan, under which calls are made and lamps cared for on request; the "contract" plan, under which calls are made, lamps cleaned and worn-out parts replaced for a stipulated sum per month; and the "free maintenance" plan, under which attention is given at regular intervals free of charge, parts being renewed at regular retail prices.

In the Passaic District of the New Jersey Public Service Gas Co. the free maintenance plan has been in operation for about seventeen months, five men devoting themselves to this work. Experience shows that the average cost of labour materials and sundry expenses amounts to 0·53 dollar per lamp, while the average receipts from sales come to 0·41 dollar per lamp. The cost to the company is thus only about 0·12 dollar (approx. 6d.) per lamp during the above period, and it is felt that the service rendered was well worth this cost.

Of the 37,653 burners inspected, 46 per cent. were found to require cleaning and adjustment. It is significant that the proportion requiring attention diminished from 50 per cent. during the first 10 months, to 39 per cent. during the subsequent seven. This illustrates the advantage of free maintenance in raising the general standard of gas lighting and removing reasons for complaint. Mr. Newman remarks: "The important thing in the gas business is to sell service. Every effort should be directed toward making the service the most efficient in every way that it is possible to give."

THE MEASUREMENT OF SUNLIGHT.

A contribution by D. T. MacDougal and H. A. Spoer to *Science* points out that conventional methods of recording the intensity of sunlight do not give the same results as would a photometric measurement of physiological brightness. The pyrheliometer gives quite distinct results from photometric readings; if a physical method of measurement be adopted photo-electric action of the sodium cell in series with a suitable galvanometer probably approaches more nearly the impressions of the eye. A comparison of all such methods with records by illumination photometer is badly needed. This is a matter which deserves the attention of investigators in forestry and similar work, where it is really the action of light from the standpoint of plant life that requires to be studied.

TESTING FLASHLIGHT CELLS.

In a paper read before the American Electrochemical Society, Mr. C. F. Burgess recently discussed the problem of testing the capacity of dry-cells commonly used for flashlights and torches of various kinds. The method consisted in discharging the cell through a resistance of 4 ohms, the P.D. being taken down to 5 volts, and the discharge made intermittently for periods of eight hours a day.

It is well known that a cell will last longer if periods for recuperation are allowed, and the question of the period of discharge is therefore important. It has been shown that the results of a comparison between different types of cells vary greatly according to the period allowed. Some fail quickly if subjected to prolonged discharge and yet give more favourable results than others if only made to yield current for short intervals of time. In view of the conditions under which such cells are normally used with flashlights it was suggested that a discharge of five minutes per day might give more truer representation of a cell's capacity, although obviously this would mean that the time taken by the complete carrying out of such a test would be considerably extended.

RARE METALS FOUND WITHIN THE BRITISH EMPIRE.

On November 16th an interesting lecture was delivered at the London School of Economics by Mr. Sydney J. Johnstone on "The Rarer Key Metals."

The variety of rare minerals found within the British Empire is surprisingly large. The only important key-metal of which supplies are scanty is platinum, which is derived mainly from Russia and Columbia. Canada may, however, furnish useful supplies in the future.

Of immediate interest from the lighting standpoint is the production of tungsten, the deposits of which in Burma have the largest output in the world, while Queensland, New South Wales, also provide material quantities. Apart from its primary use for hardening steels, tungsten is largely employed for the filaments of incandescent lamps. It is satisfactory to note that, according to the lecturer, sufficient tungsten for this purpose can now be produced in the United Kingdom. Before the war there were few metallurgical firms able to smelt the tungsten ores in any quantity, but works have been established at Sheffield and Widnes and elsewhere.

Tantalum can be obtained from Western Australia, and molybdenum, vanadium and other metals used in steel alloys also occur in various parts of the Empire.

Of special interest was Mr. Johnstone's analysis of the sources of monazite sand from which the thoria and ceria required for incandescent mantles are obtained. These deposits were formerly under German control but are now available to British manufacturers. The deposits in Brazil are relatively weak in thoria, furnishing only 4—5 per cent., while the important deposits in Travancore contains twice this amount, and therefore well repay working. Other less important deposits occur in Carolina.

The deposits in Ceylon have received special attention from the Scientific and Technical Research Department of the Imperial Institute, with which Mr. Johnstone is associated. As a rule pure Ceylon monazite contains 10 per cent. of thoria, but minerals containing as much as 30 per cent. have been found. Thorianite, also found in Ceylon, which contains as much as 60—80 per cent., according to tests made at the Imperial Institute. This mineral also contains substantial amounts of uranium oxide.

Only 1—2 per cent. of ceria is required for use in incandescent mantles, but there are other useful applications. Ferro-cerium alloys are employed as pyro-phoric automatic lighters. This substance has also been employed for tracing the flight of shells, friction with the air causing the alloy to burst into flame so that the course of the shell can be traced by the luminous "tail." Cerium earth salts have also been recently applied as a constituent of electrodes in flame arc lamps.

ILLUMINATING ENGINEERING SOCIETY (U.S.A.).

New Committees on War Work.

We understand that three new Committees have been formed by the Illuminating Engineering Society in the United States (a) to deal with problems in the illumination of aviation cantonments, (b) to standardise lighting practice in industrial establishments, and (c) to carry on investigations on problems of visibility at sea. The appointment of these Committees was mentioned by Mr. C. L. Law, the General Secretary, in the report presented at the annual meeting of the Society on October 11th.

REVIEWS OF BOOKS.

ILLUMINATING ENGINEERING PRACTICE.

A series of twenty-two lectures, arranged by the Council of the Illuminating Engineering Society (U.S.A.) and delivered at the University of Pennsylvania, September 20th—28th, 1916 *; published in volume form by the McGraw Publishing Co. (New York), and available from the Hill Publishing Co., Ltd.* (6-8, *Bouverie Street, London, E.C.*). [578 *pp.;* 5 *dollars.*]

(*Concluded from Vol. X, September,* 1917, *page* 248.)

ARCHITECTURAL ASPECTS OF LIGHTING.

A lecture by Mr. Guy Lowell is devoted to the architectural aspects of lighting. He discusses the effects of indirect illumination, the reason for the preference expressed by some artists for lighting by candles, and the problem of the amount of light to be allotted to artistic detail; as a rule it is not desirable that *all* such decoration should be clearly seen. The lecturer also draws a broad distinction between the lighting arrangements desirable in private libraries and dining rooms, and the corresponding conditions in public libraries and restaurants.

COLOUR IN LIGHTING.

The lecture on this subject by Mr. M. Luckiesh occupies thirty pages and is concluded by a useful list of references. The early part of the lecture deals with colour terminology, measurements, and mixture, on fairly familiar lines, and a short space is devoted to the physiology of vision. One of the most important practical points is the production of artificial daylight, for which a great variety of uses are mentioned. The Cleveland Museum of Art is quoted as an example of the application of artificial daylight units to the lighting of picture galleries by night. It is worth noting that when the "mellow yellow tint" of the older illuminants is desired, this can readily be obtained by a relatively slight sacrifice of efficiency, by using appropriate coloured screens with modern illuminants. Thus a gas-filled ("half-watt") lamp, normally operating at 16 lumens per watt would yield 7·4 and 11 lumens per watt respectively, when screened to simulate the colour of light from a kerosene flame, or carbon filament incandescent lamp. The efficiency in the latter case is still far above that which a carbon filament lamp would actually give.

There is also a section on coloured media, in which the properties and limitations of various dyes are discussed.

CHURCH LIGHTING.

The lecture on this subject by Mr. E. G. Perrot is furnished with illustrations showing methods adopted in a great variety of churches. Many of these are of the modern type and offer full scope for the latest illuminating engineering devices. In such cases the use of central chandeliers is deprecated. Some examples of successful concealed chancel lighting are shown, and several installations are described in which indirect or cornice lighting has been effectively employed.

LIGHTING OF SCHOOLS, LIBRARIES AND AUDITORIUMS.

The paper on the above subject by Mr. F. A. Vaughan is also well illustrated.

The fundamental requirements in school-lighting, as stated in this lecture, are closely in accordance with those recommended in this country. The following table of illumination values deserves quotation :—

Nature of Room or Work.	Illumination (Foot-candles).	
	Minimum.	*Desirable.*
Storage, corridors, stairways, etc. ..	0·25	0·25–5·0
Rough shop work ..	1·25	1·25–2·5
Fine shop work ..	3·5	3·5 –6·0
Sewing, draughting, and the like ..	5·0	5·0 –10·0
Auditorium	2·0	2·0 –4·0
Class-rooms, study-rooms and libraries	3·0	3·0 –5·0
Gymnasium	1·0	1·0 –5·0
Blackboards ..	3·0	3·0 –5·0

Reference is made to the desirability of light-tinted mat surfaces for walls and ceilings, the avoidance of excessive contrasts, and the prevention of effects which might be considered depressing. The well-known limit of contrast of 100 : 1 is spoken of with approval ; a more detailed suggestion by Luckiesh is that the brightest object permissible visible from any normal position of the observer should not exceed 250 millilamberts (say half a candle per square inch), and the maximum permissible brightness contrast in the normal visual field should not be greater than 20 : 1. This ratio might be regarded as applying to juxtaposed surfaces. Equally important is the selection of mat surfaces for books and blackboards, and the elimination of glare caused by specular reflection.

The views of illustrations of school rooms, auditoriums and libraries are interesting as showing the diversity in methods. Semi-indirect lighting seems to meet many cases.

There are one or two specially striking examples of other methods, notably the theatre auditoriums illuminated by artificial skylights, cornices, etc. A useful combination has sometimes been made of indirect ceiling lighting, and auxiliary concealed cove lighting. Yet another interesting case is the lighting of a church lobby by indirect lighting from pedestal floor standards

In libraries it is interesting to notice several methods of dealing with the rather awkward problem of lighting shelves and racks. This is sometimes done by local shaded lamps, but one interesting method, which we imagine would only be feasible in fairly low rooms and with racks not too close together, is the use of box-units resting on the top of each rack, and throwing their light up on to the ceiling.

FACTORY, OFFICE, AND PRIVATE HOUSE LIGHTING.

These three subjects are dealt with by C. E. Clewell and N. Macbeth. Mr. Clewell summarises recent legislation affecting industrial lighting, and presents a table comparing the various "codes." Some remarks are made on the classification of work according to illumination required and a table referring to a great variety of operations is presented. From this it appears that the great majority of operations are satisfied by 3—5 foot candles, that some very fine work may require 10—15, and that many rough manufacturing processes only need about 1—3 ; while for merely unloading in yards, and for warehouse work a much lower range of values, 0·1—1·0, is permissible. Typical plans are worked out and diagrams presented showing the effect of accumulations of dust, etc., on the illumination.

In the lecture on office-lighting a comparison of the merits of direct, semi-indirect, and indirect lighting is made. Some hints on spacing and the avoidance of inconvenient contrasts in desk-lighting are given. The latter part of the lecture deals with the lighting of shops and show-windows.

The lecture by J. W. Jordan on "The Lighting of the Home" deals in succession with the various rooms in the house and indicates the lighting conditions appropriate in each case.

STREET-LIGHTING.

This subject is subdivided into two parts, dealt with respectively by P. S. Millar and C. F. Lacombe. The former reviews the chief illuminants for street-lighting and places them on a chart connecting efficiency and consumption. The relation of the polar curve to distribution of light illumination in a street is also illustrated, but the author remarks that extreme evenness of illumination is not worth the very special arrangements necessary to secure it. Pictures are shown illustrating the difference in conditions in a street by day and by night, and the part played by reflection from the road surface in enabling objects to be seen against a bright background as silhouettes. A summary is given of a series of tests of ability to distinguish small targets placed on the roadway; this was regarded as a criterion of the usefulness of the lighting system in enabling persons in the street to distinguish surrounding objects. An illustration is given showing the equipment for testing the candlepower of street lamps *in situ*, with an Ulbricht globe mounted on motor-trolly. Mr. Lacombe's lecture deals largely with classification of streets according to service, and the corresponding illumination to be provided.

Of the remaining papers those by G. H. Hulse and J. L. Minick deal with lighting of railway carriages and yards, etc., while Mr. W. D'A. Ryan contributes a lecture on exhibition and pageant lighting, which is illustrated by a series of beautiful coloured views of the lighting at the Panama-Pacific Exhibition.

The Journal of the Society of Glass Technology (*Vol.* 1, *Nos.* 2 *and* 3, *July and October*, 1917; *Published by the Society of Glass Technology, Secretary Dr. W. E. S. Turner, The University, Sheffield*).

In our August issue we reviewed the first number of the above journal, and we have since received Nos. 2 and 3, which cover equally interesting ground. The former contains a paper by A. M. Rowland on "The Application of Machinery and Labour-saving Devices to Glass Manufacture" and a contribution by Prof. W. G. Fearnsides on "The General Characteristics and Sources of Supply of the Refractory Materials Required by the Glass Industry."

The chief item in No. 3, in addition to shorter contributions on American high-grade sands and other matters, is the comprehensive study by J. D. Cauwood, S. English and W. E. S. Turner on chemically resistant glassware. Detailed researches on the six best varieties of glass available are described. It is very satisfactory to note that the authors regard the British glasses now being produced as not merely substitutes for but decided improvements on the previous German best. The two numbers again contain a series of short abstracts of articles in various papers dealing with glass technology, which are well worth perusal.

Renovation of the Home in War Time by Arthur Seymour Jennings (*Constable and Co., Ltd., London.* 1/- *net.*; 86 *pp.*)

In the preface to this work the author explains that it had its origin in the troubles of a lady, whose husband is at the front and who was unable to obtain the help of local painters and decorators for the annual spring-cleaning, owing to the shortage of labour. The author accordingly prepared detailed instructions as to the materials required and their method of application which were followed by the lady with highly creditable results. These notes have now been collected into a serviceable little book. The author seems to have covered the ground very fully. He gives instructions for the cleaning of wallpapers (bearing in mind the Food Controller's veto on the use of crumbled bread or flour-paste), painting walls and woodwork, and finishing wood surfaces. Information is likewise given as to the most approved stains and enamels. At the end of the work is a miscellaneous series of recipes for such purposes as cleaning bronzes, silver and ivory, and removing stains due to grease or acid. We consider that anyone who proposes to follow the example of the gifted lady mentioned in the preface would do well to have this little book by them.

"*A Fraudulent Standard*" *by Arthur Kitson* (*P. S. King and Son, Ltd., London*, 1917; *pp.* 227; 7s. 6d. *net.*)

This book contains a development of the same idea discussed in a previous volume by the same author (*Trade Fallacies*), noticed in our last issue.* Mr. Kitson restates his objections to the gold standard and discusses the possibility of agreement upon an invariable monetary unit, forming a fixed small fraction of the total national wealth. He contends, in addition, that the time is ripe for the nationalisation of the banks of the country, the suggestion being that the Government should purchase the shares in our banks by an exchange of War Loan certificates at a just valuation. In the final chapter there is an ingenious sketch of financial conditions in the "No-money islands" in which an attempt is made to show how the author's system would work out in practice.

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* *Illum. Eng.*, September, 1917, p. 249.

RESEARCH ON FUEL.*

A useful Report, issued by the Committee of the Privy Council for Scientific and Industrial Research, summarises the chief lines of investigation being conducted by the Fuel Research Board, including the establishment of a Fuel Research Station. In their First Report (unpublished) the Board stated that they had in view two main lines of research: (1) a survey and classification of the coal seams in the various mining districts; (2) an investigation of practical problems entailed in the substitution for the raw coal at present burned in the grate of forms of fuel obtained from coal by carbonisation and gasification processes.

Among other points to be investigated is the question whether an economical and efficient apparatus can be devised for the carbonisation of properly selected coals at low temperature, and whether, by so doing, products of sufficient collective value can be obtained. This suggests a variety of subsidiary problems, some of which are briefly summarised in the Report. Among these are the obtain, ing of adequate supplies of fuel oil for the Navy by carbonisation methods, and the relation of such methods to the production of town gas and the cost of producing electric power.

But all such problems can only be solved if a thorough preliminary inquiry is made into the underlying fundamental principles.

The proposed equipment of the Fuel Research Station is fully described. It will include Retort House, Condenser and Exhauster House, Gas Holders, Gas-Producer House, Steam Boiler House, Briqueting House, Tar and Oil Stills and Condenser, Gas Furnace House, Laboratories, Offices and Workshops.

Dr. Carpenter, Chairman of the South Metropolitan Gas Co., has undertaken to give the Board valuable assistance, namely: (1) To lease to the Government at a peppercorn rent sufficient land at the East Greenwich Gas Works for the erection of the proposed Research Station; (2) to prepare drawings and specifications for this station on lines to be laid down by the Board and to make contracts for its erection; and (3) to give every facility for the transport of coal and other supplies to the station and to take over at market prices the surplus products, gas, tar, liquor and coke resulting from the operations of the Station.

A suitable site for the Station has now been agreed upon and will consist of a strip of level ground about 250 feet wide by 700—800 feet long, situated on the main siding which connects the gasworks with the South Eastern Railway and with access to an existing road.

This Research Station, as planned, will be capable of any extensions required for future researches.

CONJOINT BOARD OF SCIENTIFIC SOCIETIES.

Annual Report.

We have now received a copy of the Annual Report of the Conjoint Board of Scientific Societies, containing a summary of the activities of the Board during the past year. Reference to some of these was made in a recent issue of this journal.*

We notice that among the various Committees is one designed to prevent overlapping with work. In view of the considerable number of organisations now operating in the scientific field the formation of this committee seems a judicious step.

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* Report of the Fuel Research Board on their Scheme of Research and on the Establishment of a Fuel Research Station. (Published for the Department of Scientific and Industrial Research by His Majesty's Stationery Office, 1917. Price 2d. net.)

* *Illum. Eng.*, July, 1917, p. 184.

TOPICAL AND INDUSTRIAL SECTION.

[At the request of many of our readers we have extended the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]

THE BRITISH INDUSTRIES FAIR (1918).

The Board of Trade is again organising a British Industries Fair which is to be held on Feb. 25th, 1918. Premises have been placed at their disposal by the Port of London Authority which will permit a considerably larger space being devoted to exhibits than at the corresponding Fairs in previous years. In fact the area is officially described as being "sufficient to accomodate two full-sized Rugby Football fields."

The Fair will also be conveniently situated for business men, being only a few minutes' walk from Mark Lane Station on the Metropolitan and District Railways.

Owing to the war the Fair will be again restricted to the following trades :

Earthenware and China Trade.
Glass Trade.
Fancy Goods Trade.
Paper Stationery and Printing Trades.
Toy and Games Trade.

Firms who desire to exhibit are invited to send in applications for space to the Director, British Industries Fair, 10, Basinghall Street, London, E.C.2, the final date for the receipt of applications being November 30th.

THE "BEN-GRIP" ADAPTER.

A little adapter supplied by the Benjamin Electric Limited is a device which deserves to be widely known, in view of the drawbacks attaching to adapters of a flimsy and unreliable type. It is made of non-absorbent insulating material and provided with adequate elliptical contacts to ensure good connection, and the automatic cord-grip arrangement, which obviates the necessity of threading flexible cord through holes, is also useful. A companion device is the rotating-sleeve Edison-screw adapter, which likewise contains a cord-grip and is stated to be the smallest E.-S. adapter on the market.

B.T.H. CARD CALENDARS.

We have received from the Lamp and Wiring Supplies Department of the British Thomson-Houston Co., Ltd., a pleasing little card calendar. It is in ready and convenient form on ivory card in waistcoat-pocket size for handy reference and use. Supplies, overprinted with name and address of contractors and dealers, can be obtained on application to the Publication Department, The British Thomson-Houston Co., Ltd., "Mazda House," 77, Upper Thames Street, E.C.4.

GOOD LIGHTING FOR RETAIL STORES.

In a retail store, as in a factory, the turnover is increased by good lighting, and the business of buying and selling is made less arduous. The accompanying illustration, which shows a portion of the installation (in the Linoleum Department) at Messrs. Hammond Ltd., Hull, is interesting from this standpoint.

These stores have been equipped throughout with Mazda Half-watt Lamps in conjunction with semi-indirect fittings.

The lighting is stated to be exceptionally well diffused and uniform, and is well adapted to the illumination of large vertical surfaces, such as prevail in this department.

We are informed that the whole of the lighting scheme for Messrs. Hammonds was planned and the fittings and lamps supplied by the British Thomson-Houston Co., Ltd. (Mazda House, Upper Thames Street, London, E.C.).

Lighting with Mazda Half-Watt Lamps and semi-indirect fittings of the Linoleum Department of Messrs. Hammonds, Ltd., Hull.

MINISTRY OF MUNITIONS.

Official Photographs and Samples of Women's Work.

Another exhibition of women's work took place last month at the City Art Gallery, Birmingham, illustrating the various types of work upon which women are employed in engineering and other industries on Munitions of War.

The exhibition was opened by the Lord Mayor of Birmingham on Monday, October 22nd, and terminated on November 10th.

Like the preceding exhibitions of this kind at other great industrial centres, the exhibits were successful in showing how many are the forms of skilled engineering and optical work which are now being undertaken by women's labour.

Assets exceed £2,500 000.

Claims paid over £8,500,000.

By Appointment.

GENERAL

Accident Fire and Life

ASSURANCE CORPORATION, Ltd.

General Buildings, Perth, Scotland.
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Established 1885.

WAR ECONOMY.

In consequence of the War, the cost of building material and labour has increased nearly 50 per cent. All owners of property should therefore increase their Fire Insurances; this they can do at little or no extra cost by taking a Fire Bonus Policy with this Corporation, and thus effect a saving of 20 per cent. of each premium.

Particulars on receipt of post card at either of the above Offices.

F. NORIE-MILLER, J.P.
General Manager.

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To whom Notice of Claims under the following conditions must be sent within seven days of accident

£250 TWO HUNDRED AND FIFTY POUNDS will be paid by the above Corporation to the legal personal representatives of any person who is killed by an accident causing material damage to the passenger train in which the deceased was travelling as a ticket bearing or paying passenger, or who shall have been fatally injured thereby, should death result within one calendar month after such accident. **Provided** that the person so killed or injured had upon his or her person, or had left at home this coupon, with his or her usual signature, written prior to the accident, in the space provided below, which, together with the giving of notice within seven days to the above Corporation is the essence of this contract.

This Insurance only applies to persons over 14 and under 65 years of age, is subject to the conditions stated above and contained in the General Accident Fire and Life Assurance Corporation Act, 1907, and holds good for the current month of issue only.

No person can recover under more than one Coupon Ticket in respect of the same risk.

Signature ....

This Coupon must not be cut out but left intact in THE ILLUMINATING ENGINEER as that being dated, forms the only evidence of its currency.

LLOYD'S DIAGRAM FOR CALCULATIONS.

The above name is attached to a chart to facilitate calculations, issued by Messrs. E. and F. N. Spon, Ltd. The chart carries two identical horizontal numbered scales at top and bottom, and similar duplicate vertical scales on the left and right. The latter numbers are connected by horizontal cross lines, while the former are linked by both vertical lines and sloping lines shaded red. The intervals between successive numbers are so proportioned that inspection of the chart enables the result of multiplying any number in the horizontal scale by another number in the vertical scale to be readily determined. There are also additional sloping lines to enable squares and cubes or square and cube roots to be ascertained.

The chart thus fulfils functions similar to those of a slide rule. While it is naturally necessary to become familiar with its working in order to use the chart with ease and convenience, the device should be helpful to engineers and others wishing to get rapid and approximate results. The price is 2s. 6d.

THE APPLICATION OF GAS TO WAR INDUSTRIES.

A recent issue of *A Thousand and One Uses for Gas* illustrates some interesting processes in munition factories in which gas-heating plays an essential part. Among these are included annealing tool-steel bars in oven furnaces, case-hardening of component parts of rifles, furnaces for annealing wire, the re-heating of motor-cycle parts, &c. Other illustrations show the application of gas in non-ferrous processes, *e.g.*, for the melting of brass, copper, and aluminium.

Some very striking figures are given for the increased gas consumption in various industrial towns ; in some cases the amount of gas used in 1916 exceeds by over 100 per cent. that employed in 1913. Similar data are given for nine typical war factories, where, in one case, an increase of 3,314 per cent. is actually recorded.

THORIUM FROM THE UNITED STATES.

It is well known that one of the greatest difficulties experienced by the incandescent mantle industry upon the outbreak of war was the cutting off of the thorium and cerium supplies which had been obtained from the German monopoly.

Special interest therefore attaches to the efforts of the Lindsay Light Co., of Chicago, who stepped into the breach by immediately putting down a new plant for the preparation of these materials. We observe that this plant now requires the attention of over 80 men, with 12 vats working 144 hours a week and using 2½ tons of monazite sand a day. According to the *Gas Record*, the total thorium output for the year is sufficient for nearly 150,000,000 mantles. The product is guaranteed to contain 48 per cent. oxide and is manufactured with scrupulous care. Messrs. Paul Winn & Co., Ltd. (72, Mark Lane, E.C.), are the sole agents for Europe.

BARIMAR THERMIT WELDING.

We understand that the Board of Trade have now given formal sanction to a new company, with works in London and Liverpool, and known as the British Barimar-Thermite Welding Co., Ltd., to take up and exploit the thermit welding process which, prior to the war, was exclusively in German hands.

Thermit is stated to be specially applicable to tramway welding and for the repair of heavy castings and machine parts, and it is the intention of Mr. F. W. Brett, the Managing Director and General Manager of Barimar, Ltd. (who is largely responsible for the formation and management of the new company), to train disabled British soldiers and sailors to carry on the work. The registered offices of the new company are at Poland Street, London, W.1.

The
ILLUMINATING
ENGINEER
·ELECTRICITY· ·ACETYLENE· ·OIL· ·GAS·
Edited by
LEON GASTER

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EDITORIAL.

Progress in Illumination in the United States.

In this issue (pp. 285—289) we present a summary of the very valuable account of progress in illumination, compiled annually by the Committee on Progress of the American Illuminating Engineering Society, and presented for the Convention (conducted by correspondence owing to the war) in September last.

It is natural to find that the developments during the last year have been in the direction of steady progress and new applications of light, rather than the evolution of new types of lamps and fixtures. The entry of the United States into the war has naturally led manufacturers to concentrate their attention on increase in output of standardised articles, and many promising lines of investigation have doubtless been deferred for the present in all the belligerent countries. After the war many interesting developments may be brought to light.

As indicative of the tendency towards standardisation, it is worthy of notice that the voltages of electric incandescent lamps are now being confined to well-defined limits, and that in the gas industry a movement is in progress for a systematic rating of gas lamps, on lines comparable with those adopted in defining the candlepower of electric units.

Perhaps the most striking field of work during the last year has been the greatly extended use of flood-lighting, largely for protective purposes. The method can, however, be applied in many different ways, and it was recently estimated that 97 different uses of flood-lighting had been evolved.

In many directions the illuminating engineering movement has been making itself felt, for example, in connection with legislation on motor-car headlights, and on industrial illumination. The Codes on Factory Lighting in the States of Pennsylvania and New Jersey have been in operation for a year, and have been found satisfactory in nearly all respects. The Wisconsin Industrial Commission has formed a committee to revise its legislation dating back to 1913, and the United States Public Health Service is acting in co-operation with this committee with a view to promoting better lighting in factories. The Ohio Industrial Commission is also arranging for the drafting of a code on factory lighting, so that the recognition of the importance of the subject on the part of the authorities is evidently growing.

When one surveys this record of progress one is struck by the wideness of the ground covered. In connection with photometry the integrating globe has been the subject of special study, and appears to be developing into a practical apparatus for commercial tests. Work has also been done on various kinds of photo-sensitive cells, and there seems a prospect that this form of physical photometry may have special applications in determining the brightness of stars, in researches on the relation of light to plant growth, and in other special fields. There have also been attempts to develop illumination photometers of a simpler type, two of which are based on the limit-gauge principle, originally suggested by Mr. A. P. Trotter.

In connection with interior lighting, we note a steady tendency towards the use of more scientific methods, notably the use of concealed lighting effects in theatres, cinema halls, and other rooms where avoidance of glare is a very essential factor. Street-lighting in the United States seems to have been so far following a normal course, but the special measures taken in this country to reduce the lighting to meet war conditions have been closely studied, and the discussions on this subject before our own Society are reported in some detail.

Many other corners of the field of illuminating engineering are explored, *e.g.*, the researches made in this country on radioactive luminescent paint, and other phosphorescent and fluorescent effects, the emission of light by certain self-luminous insects, and the work of the United States Weather Bureau in defining "civil" and "astronomical" twilight. A point of some interest, to those concerned with fuel economy, is the diminution in the value of daylight illumination through smoke in industrial cities. In some cases, a diminution of 30—40 per cent. on clear days has been noted.

The impression one gathers is that the stream of research in connection with illumination, though interrupted here and there, is still flowing strongly, finding new channels when progress in accustomed directions is denied.

The Metric System.

Since the outbreak of war the supporters of the metric system have not failed to appreciate the opportunity provided for raising the question of a change in coinage, weights and measures to the metric system. The general disturbance of trade values, inconvenient in other respects, would, it is suggested, make the period of transition from one system to the other easier than in normal times, and there is also the favourable circumstance that men serving with the Forces on the Continent will have had an opportunity to become familiar with the metric units.

While the matter is receiving special attention at the present time, the subject has of course often been debated. From a chronological statement recently published in the *Electrical Review*, it appears that the substitution of a "pound and mil" system of coinage was proposed in a discussion in the House of Commons in 1824, while in 1841, after the destruction of the Houses of Parliament by fire, the Commission on the Restoration of Weights and Measures reported in favour of the decimal system. More recently, in 1907, the House rejected, by the narrow majority of 32, a Bill for the compulsory introduction of the metric system, and the Australian House of Representatives, three years later, resolved to adopt the metric system as soon as it became compulsory in Great Britain.

The whole subject has been ably presented in two recent papers before the Institution of Electrical Engineers by Mr. A. J. Stubbs and Mr. L. B. Atkinson. As a matter of principle the simplicity of the metric system, especially the statement of weights directly in terms of volumes and specific gravity, has much to recommend it. In scientific work it is almost exclusively used, and it has already been adopted in many fields of engineering work.

Suggestions have been made that we should avoid some of the difficulties of the change by retaining most of our primary units but adopting a special duo-decimal system of subdivision. We do not think, however, that the adoption of such a system is likely to command general support. If the change is to be made it would seem preferable to adapt ourselves once and for all to the measures prevalent throughout the rest of the civilised world. In the future, when trade relations with foreign countries will occupy a large share in public attention, the advantages of adopting a system corresponding as closely as possible to that in use abroad will no doubt carry great weight.

The chief objection commonly urged against the change is the large amount of disturbance involved and the loss entailed in scrapping existing weights, measures, and measuring appliances based thereon, and the revision of arrangements of payment based on existing coinage. It should, however, be borne in mind, as Mr. Stubbs points out, that the loss will be distributed throughout the country, and that the sacrifice of each individual, for example, in purchasing a new set of weights, will not in general be heavy. Naturally, measures would be taken to render the transition as easy as possible.

Summing the matter up, one may say that there are many reasons to desire the ultimate adoption of the metric system, but at the same time the magnitude of the change, and the dislocation of existing practice which it would cause, have to be carefully considered. The decision should be based on a comprehensive survey of the industrial field, and in the meantime consideration of the problem by technical societies and industrial bodies can do a great deal to prepare the ground for the future.

The Metric System and Illuminating Engineering.

So far as the lighting industry is concerned, a change to the metric system would not present greater inconvenience than in any other section of industry; in some respects it would probably be less. There would naturally be a period during which the dimensions of lamps, reflectors, etc., were specified both in British units and in the metric equivalent. The ultimate adoption of centimetres and millimetres, and the disappearance of the inconvenient 1/8ths, 1/16ths, and 1/32ths of an inch assigned frequently to galleries, holders, etc., would be a blessing.

In regard to electric lamps, we have already gone some distance towards the metric system and the adoption of Continental measures. We no longer speak of 8, 16, and 32 c.p. lamps, but of 20, 30, 50, 100 watt units, etc. Specific consumption is still expressed in candles per cubic foot per hour, but familiarity with Continental literature would make the transition to litres comparatively easy. Again, in dealing with kilowatts and 1000's of cub. feet of gas, we are already using a decimal system.

In one respect we are certainly favourably situated. We have a unit of candlepower which is likewise accepted by the United States and France, and which is easily convertible into the only other unit of consequence, the Hefner. The Lumen is independent of the unit of length adopted, provided the unit of candlepower is the same. The foot-candle would presumably be replaced ultimately by the lux (metre-candle), but the transition is not difficult, if it is remembered that the lux is approximately one-tenth of the foot-candle.

It is sometimes urged that numerically the foot-candle is a more convenient unit than the lux, in that it represents an amount of illumination which is commonly used and has come to be regarded as a rough standard for general work. On the other hand, there is less force in this contention than there would have been a few years ago. The tendency for some years has been towards higher values, and for many purposes where we should have formerly been content with a foot-candle, we should use more to-day. The older writers, for example, not infrequently specified one foot-candle as sufficient for ordinary reading and writing. To-day this is hardly considered sufficient. The Joint Committee of the Illuminating Engineering Society in 1913 suggested a minimum of two foot-candles for desks in schoolrooms, and for many factory operations five foot-candles or more are now not uncommonly provided.

From this standpoint there is therefore less objection to expressing illumination in lux. This would, in general, avoid the use of decimals, and in street-lighting, where we may go down to 0·01 foot-candle, the multiplication of values by 10 would seem to be an advantage.

On the whole, therefore, the transition to metric values in illuminating engineering would not impose very great difficulties, and owing to the fact that the movement has been essentially international, we are, as a body, more conversant with the metric units than would be the case in many other industries. When the time comes for the conversion from British to metric units to be taken in hand we should be quite prepared to publish values on the old and new basis simultaneously for a time, and in this way prepare the ground for the final alteration.

LEON GASTER.

A YEAR'S PROGRESS IN ILLUMINATING ENGINEERING.

Abstract of Report prepared by the Committee on Progress (consisting of F. E. Cady (Chairman), E. F. Kingsbury, W. B. Lancaster, R. ff. Pierce, and T. W. Rolph) of the Illuminating Engineering Society in the United States, for the Correspondence Convention, September—October, 1917.

In the introduction to this Report the Committee remark that the past year has been marked by a steady growth in the perfection of methods rather than by striking developments. Owing to the war there has been little time for the spectacular, and novelties and new developments have been held in abeyance. The effect of the war has been noticeable in connection with the extension of flood-lighting for protective purposes, and in the night-illumination of factories working to fill increased orders.

Gas Lighting.

Among other matters reference is made to recent researches on the early history of gas lighting in New York City, to the development of monazite deposits in Ceylon, and a new gaseous mixture discovered by a Swedish chemist as a substitute for acetylene. This compound is produced by the decomposition of calcium carbide and hydrocarbon oils. The colour of the flame is whitish, and it is said to be applicable for use with incandescent burners.

There have been experiments on new materials for gas production, a French company having tried to use wood for the purpose. At the existing high price of coal the process is said to be practicable.

A self-shaping high candlepower inverted gas mantle stated to be unaffected by dampness or climatic changes and made of special fibre is mentioned.

In co-operation with the Bureau of the American Gas Institute the Bureau of Standards is making an experimental study of the rating of gas lamps, and the influence of pressure. An interesting development in England is the offer of one gas company to supply upright or inverted burners free in place of flat-flame burners. In America there is a similar tendency in this direction. The adoption of a calorific standard for gas is becoming general and the Bureau of Standards is studying the influence of calorific power on various incandescent gas lamps. The New York State Public Service Commission has fixed the calorific standard in the second district of New York at 585 B.Th.U., a monthly average.

Electric Incandescent Lamps.

The sale of carbon filament lamps has not diminished as rapidly as might be expected. The 50-watt tungsten lamp has come into more general use. Manufacturers are concentrating on a standard range of 10, 25, 50, 75, and 100 watt lamps, while a 150-watt gas-filled lamp has been introduced and is a useful intermediary between the 100-watt and 200-watt types. A decided increase in the number of small lighting outfits in homes where no central station supply is available has led to the development of a special line of lamps adapted to a battery of 16 accumulators. The rise in the average candlepower of lamps supplied still continues, being now almost three times what it was ten years ago.

As regards new developments, attempts have been made in Germany to use carbon filaments in an atmosphere of mercury. The drawing of tungsten wire for lamps is being adopted in Japan, and a new German process is mentioned for drawing tungsten wire only a few hundredths of a millimeter thick, and octagonal in cross section. The tungsten is mixed with two per cent. thoria and squirted, being subsequently consolidated at a temperature of 2,400°—2,600° C. The use of crimped ribbon tungsten has been proposed for very high candlepower lamps, as giving a large radiating surface and being less fragile.

As a result of recent research soda appears to be a possible substitute for potash for the making of glass for lamp-bulbs.

Lamps with special blue glass bulbs to imitate daylight are making progress. An interesting application of such lamps is in laundries, where it is found that scorching, giving rise to brownish spots, can be more easily detected by this light.

Arc Lamps.

A number of researches on arc lamp carbons are reported. Many of these deal with the problem of avoiding the formation of insulating slag on electrodes. The addition of borates and other alkali salts has been found helpful in this respect, and boracic acid is stated to be specially good for open-type lamps. With positive carbons containing 30—40 per cent. of luminous salts, 3—5 per cent. of boracic acid is used. The average time needed to trim a lamp in actual service has been found to be 1 minute 40 seconds. It has been found impossible for a man to trim more than 100 lamps in one day.

The arc lamp has found an interesting application for the practical manufacture of chemicals. Experiments, for example, have shown that the white flame arc lamp can be used to accelerate the chlorination of natural gas in the production of chloroform.

Vapour Lamps.

Two new types of mercury vapour lamps, one for alternating, the other for direct current, and operating at 200 volts are announced. They are intended for use in situations where low head-room is desirable.

Various experimental lamps due to Prof. Nernst are mentioned. One of these depends on an arc between carbon electrodes in a mercury atmosphere, the efficiency being similar to that obtained with mercury lamps. The other lamp has for its principle the addition of salts which fuse at the temperature of mercury vapour. This lamp is stated to yield 3,000 candles (Hefner) on 120 volts at 4 amps., thus working at 0·16 watt per Hefner.

It has been found that by making the positive electrode of a mercury lamp of thallium or caesium its efficiency as a source of ultraviolet light is much increased.

Projection Lamps.

Many small portable moving picture projection outfits have been put upon the market, both for private use and for the use of salesmen desiring to exhibit moving machinery in operation. Incandescent tungsten lamps with concentrated filaments are used for this work. Another development has been the demand for pocket flashlight lamps; a lamp of this kind for trainmen, having a red bulb one end and a clear bulb at the other, has been introduced.

A brief description is given of the most recent type of searchlight with cooled electrodes, which has been already dealt with in this journal.

The tendencies in automobile headlights are also shortly summarised. The Interstate Commerce Commission has investigated the carrying power of locomotive headlamps. A standard 250-watt 32-volt lamp with an 18 in. by 9 in. reflector, was employed. At a speed of 20 miles small objects on the line could be distinguished at a distance of 800 ft., and at 1,000 ft. with the locomotive at rest. Researches have also been made on the yellow glass used in signal lanterns, with a view to getting the best colouration and minimum absorption. It is proposed to eliminate white lights from signalling arrangements owing to the increasing use of such lamps for other purposes.

A light-signalling apparatus for ships at sea has been devised to prevent collisions between vessels in fog. It is based on the fact that in general the fog or mist is less thick near the surface of the water. Accordingly, lamps and observers are stationed as low down as possible.

In regard to miners' lamps the tendency is towards heavier and more substantial types. A nine-hour acetylene lamp has been recently introduced. The Bureau of Mines has recently approved an electric unit having a ½-candle incandescent lamp with a life of 300 hours. It weighs only 4 oz.

Effects of the War.

The matter in this section covers familiar ground, frequent reference being made to discussions before the Illuminating Engineering Society in London in regard to street-lighting, the effect of public illumination on the frequency of accidents, etc. Tests at the National Physical Laboratory have shown that on a dark night the light of an ordinary match may be distinguishable at a distance of one mile, which forms some justification for the prohibition of lighted matches, cigarettes, etc., on the fronts of important coast towns.

Considerable attention is devoted to the protective uses of flood-lighting. A list of 97 different applications for such lamps has recently been prepared. For the illumination of specified objects 2—10 foot-candles, and a watt consumption of 0·2—5 watts, according to the conditions, are required. An account of recent installations for the lighting of public buildings, and for the guarding of important bridges, factories, etc., is given. An interesting development is the application of this method to the illumination of air-break switches, lightning arrestor-gaps, etc., on high-tension installations, where the large distance apart of poles renders impracticable ordinary methods of lighting. Flood-lighting has been used for the production of ornamental effects in parks and gardens, and, on a small scale, it has been suggested as having a useful application to the cultivation of allotments, enabling work to be done at night.

Flood-lighting with gas is also coming into use. In some instances ordinary curb-posts have been used to carry projectors.

Exterior Lighting.

In the Street-lighting Section the developments in lighting of a large number of American cities are summarised.

Several examples of special exterior illumination are given, a novel device being the mounting of diffusing glass panels, carrying lamps behind them, in the face of buildings. In one case the glass insets were arranged to give the effect of marble-veining in the daytime.

The American Association of Agricultural Engineers has recommended standard rating and specifications for farm-lighting equipment, and this has been the subject of study by a representative of the Chilean Navy. In sign-lighting the tendency is towards the use of transparencies, in view of their artistic possibilities and freedom from glare.

Interior Lighting.

The Health Department of the City of New York has undertaken a sanitary survey of a trial block in order to ascertain the conditions under which operators work in various parts of the city. Enormous variations in the amount of light used are noted, and over 85 per cent. of the rooms visited were found to require artificial light in daylight hours. Ceiling lights are rarely sufficiently powerful, and therefore local lights giving 8—9 foot-candles are recommended for desks, typewriters, &c.

A block of shops in New York City has also been equipped with model lighting to serve as a demonstration. A novel decorative system attempted in one building is the combination of indirect sources giving light of different colours so as to produce pleasing colour-effects on the ceiling, but to yield a general illumination which is practically "white."

The Public Health Service has been making a study of the lighting of steel plants and its effect on the eyes of workmen. In the lighting of auditoriums and theatres the tendency is towards concealed sources. The use of blue-bulb tungsten lamps for Art Galleries is increasing.

Glassware and Fixtures.

Various new developments of prismatic glassware are mentioned, for example a diffusing unit made up of an upper reflector and a lower glass distributor provided with concentric corrugations, which are frosted at the crest or apex and transparent on the other side. Another indoor reflector has a body and shield of pure white enamel and between them a prismatic band for the transmission of light rays reflected from the top. Yet another unit consists of two parts, of which the indirect reflector is made of porcelain-enamelled steel, while at the bottom is a glass diffusing plate made in one piece with an envelope of moulded glass, easily detachable.

A new industrial unit, specially intended to eliminate glare, is made up of a polished metal cap fitting over the pip of the lamp itself so as to cut off direct radiation, and an inverted pan-shaped porcelain-lined reflector 20 inches in diameter. A novelty of interest in theatres is the adoption of "disappearing footlights."

A detailed survey of the distribution curves of a large number of globes, shades and reflectors has been undertaken by the Petrograd Polytechnic Institute. Tests were also made on the effect of dust and the conclusion was drawn that in an average installation fixtures should be cleaned thoroughly once a month, and dusted once between cleaning.

Photometry.

Various arrangements of mirrors have been adopted to employ the device of determining mean spherical candlepower of lamps by measurements in zones 36° above and below the horizontal. Special attention has been given to the integrating sphere, and attempts are being made to standardise the method. As a result of 20,000 observations of various kinds of photometric measurements it has been found that the precision obtainable, with a colour match, in the Lummer Brodhun photometer is approximately 0·3 per cent. With a flicker photometer, independent of colour difference, the precision was 0·75 per cent. Two observers, one working in the field of gas lighting and the other in electric lighting, have independently developed portable photometers based on the Trotter "Limit-Gauge" principle.

It has been found that with a proper form of photo-electric cell the deviation from the straight line law connecting current and illumination is very small, and that the cell can be used for many photometric purposes, *e.g.*, in stellar photometry, plant physiology, &c., and for measuring coefficients of reflection and absorbtion.

Luminous Paints and Bacteria, etc.

Experiments made on the testing of luminous paints in this country are summarised.

There is also an account of recent experiments on luminous insects and bacteria of various kinds. One Japanese insect is said to contain enough chemical material to enable an analysis to be made. A study of the production of light by easily oxidisable amino-phenols has shown that only pyrogallol gives off appreciable light, of an intensity closely approaching the production of luminosity by luminous bacteria.

Two specimens of substances which reveal marked influence to light are acicular crystals of bismuth sulphide and granular antimony sulphide; a piece 1 mm. by 10 mm. of the latter, under an applied voltage of 110, showed a resistance in dull sunlight reduced by about 5,000 per cent. from the value in the dark.

Various.

Among other experiments which may be grouped under this heading may be mentioned an attempt by the Bureau of Standards to develop a standard method of specifying the transparency of tracing cloth, based on the reduction of contrast between standard dead black and dead white materials.

Glasses are still being developed for the protection of the eyes from ultra-violet or infra-red energy, and screens have been prepared commercially for transmitting various regions of the spectrum.

The Weather Bureau in the United States has been making a series of measurements on daylight and moonlight, and has found that at the instant of sunrise or sunset the illumination is about 1,650 times as intense as that of the zenithal full moon. "Civil Twilight" and "Astronomical Twilight" have been defined by the Bureau as occurring when the sun is respectively 6° and 18° below the horizon. Results on tests of the effect of smoke in the atmosphere in cities where soft coal is burned in reducing illumination are also published. A diminution of from 30 to 40 per cent. was observed on clear days.

Legislation on Illumination

The factory lighting codes adopted in Pennsylvania and New Jersey have been in operation over a year and have been found in the main satisfactory. The Wisconsin Industrial Commission has formed a committee to consider redrafting its existing orders of 1913. The United States Public Health Service has been asked to co-operate with this Committee and with the American Illuminating Engineering Society in securing better lighting in factories. The Ohio Industrial Commission has arranged to have a lighting code prepared.

Until a few months ago only seven States had any regulations bearing on automobile headlights. Two others (New York and Ohio) have recently enacted that the reflected beam shall not rise more than 3·5 ft. above the level surface of the road at a distance of 75 ft. Municipal regulations on this subject are many and widely different, and in sixteen States the use of glaring headlamps is restricted by local ordinances. in towns and cities.

Finally reference is made to the effect of the Daylight Saving Act in Europe. In France the saving effected is calculated to amount to 1 ton of coal per month per 1,000 inhabitants. The adoption of the measure is being favourably considered in the United States.

ILLUMINATING ENGINEERING PUBLICITY.

A recent paper before the American Illuminating Engineering Society by Mr. G. H. Stickney draws attention to a number of points that occur in connection with the publicity of illuminating engineering, *i.e.*, statements of the performances of lamps and lighting appliances made to the general public.

As a fundamental principle it pays an advertiser to state what is literally true; fortunately deliberate misrepresentation is now rare. Naturally, in advocating the claims of a new lamp or lighting appliance, recourse is often had to comparisons. But this practice needs to be used with care, and, generally speaking, it is advisable for an advertiser to refrain from comparisons between his own product and that of a competitor. His statements are apt in this case to be discounted as prejudiced.

If comparisons are made they should be in terms of units of the same power; it is unfair to compare a high candlepower unit with a much smaller and generally less efficient one in another class.

In many instances the performance of a lamp may be affected by variable conditions of use, *e.g.*, variation in voltage supply, gas pressure, &c. A company will naturally desire to present results under the most favourable conditions; but it is desirable to supplement such statements by education of the public regarding the best way of using the unit advertised.

In regard to illuminating value, the variation of candlepower in different directions needs to be carefully set out; much inconvenience was caused by the prevalence at one time of exaggerated claims for the ordinary arc lamp. From its standpoint statements of output in lumens have a distinct advantage, being less liable to misrepresentation.

Efficiency is no longer the only "talking point." In some cases other factors are now perhaps emphasised unduly; for example makers are apt to put forward lighting appliances as though they, and only they, were "free from glare"; whereas glare can be eliminated in a number of ways.

In regard to colour-values, precision of statement is particularly to be desired. In dealing with the so-called "artificial daylight" incandescent electric lamps with blue bulbs, the limitations as well as the undoubted merits of such appliances should be understood.

Finally the author attaches great importance to photographs of installations taken solely by the artificial light. Here again the limitations of the method must be borne in mind. The effect shown is dependent on the good faith of the photographer; retouching is best avoided, as in general the retoucher does not see the original installation and may therefore convey a wrong impression.

"ARTIFICIAL DAYLIGHT" AS AN AID TO NATURAL ILLUMINATION.

The application of "artificial daylight" units to special purposes where accurate colour-matching is necessary has frequently been noticed. Such units have now distinct possibilities for reinforcing natural illumination for ordinary purposes. People who refer to the diffused uniform effect of daylight do not as a rule recognise the very wide variations that occur in an average room. If the light is derived from windows on one side of a room only the horizontal daylight illumination thirty feet back from the windows may be only 1-30th (or even less) of that at a table immediately in front of them. When the daylight begins to fail it is therefore in these sections of the room that the difficulty in reading is first experienced. In many London offices these remote portions of the room may receive insufficient light even at noon.

The natural course is therefore to supplement the daylight by local artificial lighting. But this is open to the familiar objection that the two qualities of light do not "mix" satisfactorily, so that the transition from daylight to full artificial light is always inconvenient. In cases where the addition of local artificial light, as an adjunct to daylight, is habitually necessary the new gas-filled electric lamps with special "daylight" glass bulbs seem to have advantages. It is stated that the latest lamps of this kind have an efficiency not far removed from that of an ordinary tungsten lamp and their light resembles daylight sufficiently closely to avoid the inconvenient contrast in colour referred to above.

STANDARDISATION OF LAMP-VOLTAGES IN CANADA AND THE UNITED STATES.

In a recent paper before the Philadelphian Section of the Illuminating Engineering Society (U.S.A.) Mr. U. Rasin remarked that in the year 1916 about 60 per cent. of all the lamps used in the United States were rated at 110, 115, and 120 volts, and that the greater number of the remainder were rated between 112 and 125 volts. We understand that the conditions in Canada are very similar so that the above range series of three standard voltages is rapidly becoming general.

Naturally this will be a great advantage to the electric lamp industry. In Great Britain not only have lamps to be provided for voltages varying from 100—130, but for the additional range of 200—260 volts. It would obviously be a great step towards further simplicity if standardisation in Great Britain could be effected so as to limit the pressures to 110, 115, and 120 volts for low-voltage lamps, and 220, 230, and 240 volts in the higher voltages; the numbers in the upper register being exactly twice those in the lower one.

PYROMETRY.

An important series of papers on pyrometers was presented before the Faraday Society on Nov. 7th. Several papers dealt with the properties and applications of instruments of the thermoelectric type, including a contribution by Dr. E. Griffiths and F. H. Schofield on Pyrometer Standardisations. Mr. H. Watkin also presented an interesting paper describing various devices that have been used in the pottery industry to indicate the correct firing temperature, for example, those based on the contraction of a standard clay object under the influence of heat.

CHARACTERISTICS AND TESTING OF SEARCHLIGHTS.*

By Lieut. S. G. Hibben.

Since the outbreak of war considerable advances have been made by American and foreign manufacturers in the development and manufacture of searchlights. The most usual semi-portable type of lamp employed at the present time utilises a 60-in. mirror and stands about 12 ft. high. Motors with distant control are geared to elevate and depress the projector or revolve the barrel about the vertical axis. Hand wheels are also provided for this purpose and to set the electrodes in the proper positions. Such a 60-in. projector, working at 20,000 watts, will yield about 200,000,000 candles.

The sizes of carbons used are indicated in the following table :—

Projector. Diam. of Mirror (inches).	Negative Carbon Diam. in inches.	Positive Carbon Diam. in inches.
18	$\frac{5}{8}$″ solid	$1\frac{3}{16}$″ cored
24	$\frac{3}{4}$″ cored	1″ ..
30	$\frac{7}{8}$″ ..	$1\frac{1}{8}$″ ..
36	1″ ..	$1\frac{1}{4}$″ ..
60	$1\frac{3}{8}$″ ..	$2\frac{3}{8}$″ ..

The average life of the carbon electrodes used in the 60-in. type of searchlight is about six hours.

It is more important that the generator units should be reliable in action than that they should be highly efficient. They are subject to rough conditions and must not be affected by moisture, rain or abnormal temperatures. A 25 k.w. unit will consume about 6 gallons of gasoline per hour. In a typical 60-in. projector the arc P.D. is about 55 volts and the current nearly 180 amps.

The ratio of diameter of mirror to focal length is practically a straight line function. In the present state of manufacture it is impracticable to make Mangin mirrors of diameters exceeding 60 inches. The focal length must be too short on account of the danger of the heat from the arc cracking the mirror. On the other hand the greater the focal length the smaller the proportion of light that strikes the mirror. The dispersion is least when the ratio of crater-diameter to focal length is a minimum. For a $\frac{3}{4}$ in. diam. crater, a 36-in. mirror and a 15-in. focal length the total spread of the beam is $\frac{3}{4} \div 15$, *i.e.*, about 3 degrees. There will also be some dispersion caused by the front glass. The combined absorption of light by the mirror and front glass may be in the neighbourhood of 20 per cent. In normal circumstances, with currents from 160—180 amps., the maximum effective crater candlepower is about 50,000, and the intrinsic brilliancy of the crater is then about 80,000 candles per sq. in.

The temperature of the positive arc crater is from 4,000°—5,000° C., and for high-current densities the carbon holders must be cooled.

Approximate values of beam candlepower can be calculated by the following formula :—*

$$1 = X\frac{(d)^2}{(c)^2}$$

where

1=intensity of projected beam of light.
X=intensity of light striking mirror (c.p. of arc crater).
d=diameter of mirror in feet.
c=diameter of arc crater in feet.

This formula does not take into account the atmospheric and glassware absorption. Applied to a 60 in. projector with an arc crater of 1·1 in. and a crater candlepower of 49,000 this formula gives a maximum beam candlepower of 151,000,000.

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* Abstract of an article in the *Electrical World*, September 1st, 1917.

* This formula is equivalent to the general rule: c.p. of beam = area of mirror × intrinsic brilliancy of crater.

A better method of estimating the effective value of a searchlight is to measure the actual illumination received on a target at a specified distance.

The following values for a target at a distance of 2,730 feet, are of interest :—

Current in Arc (amperes.)	Illumination on Target (foot-candles.)
20	0·4
25	0·7
40	0·9
60	1·0
90	1·0

Owing to the fact that there is always a certain amount of atmospheric absorbtion it is usually impracticable to work at a greater range than about 6,000 feet. The ranges at which targets of gray or medium light colours may be satisfactorily illuminated by a 60-in. searchlight are as follows :—

Atmospheric Conditions.	Range in yards.
Very clear atmosphere ..	10,000 or more
Average atmosphere	6,000—8,000
Slight haze or rain	3,000—4,000
Fog or early dawn	1,000—2,000

Cases are, however, known in which vessels have been located at a distance of nine miles, and on slightly foggy nights the beams may be seen in the sky at still greater distances.

In experience it is found that it is best to illuminate as little of the foreground and surroundings as possible in order to minimise glare through reflection and avoid disclosing to the enemy the position of the searchlight. The most favourable direction of the beam of light is found to be 30° with the line of fire.

PROTECTIVE FLOOD-LIGHTING IN THE OILFIELDS.

In the *General Electric Review* another interesting instance of the use of flood-lighting for protective purposes is mentioned, namely, in the oilfields of Oklahoma, where one thousand 55,000-gallon tanks of oil are located. Great damage could be done by fire, and a guard has been installed against any possible hostile action.

In addition flood-lighting equipments have been mounted on the top of special derricks 42 ft. high, at the top of which look-out towers 8 ft. in height are situated. The flood-lighting projector is six feet above the top of this look-out tower and is thus 56 ft. above the ground. The observer in the tower can thus illuminate and survey a very wide area. Similar stations are located throughout the field at intervals of about a mile apart.

THE MINIMUM RADIATION PERCEPTIBLE TO THE EYE.

A contribution on this subject to a recent number of the *Astrophysical Journal* by P. Reeves summarises the work of various observers. These researches are of interest in connection with observations of stellar magnitudes, as well as having a bearing generally on problems in which the location of distant faint lights is involved. Experiments can conveniently be made on an artificial star, produced by means of a small aperture 1 mm. in diameter having behind it a translucent screen illuminated by an artificial source of light and viewed at a distance of 3 metres. The brightness of the aperture could be adjusted by means of decimal neutral filters and wedges.

Naturally the minimum intensity perceptible varies according to the sensitiveness of the eye of the observer, his state of health, the condition of adaptation of the eye, and the pupil-aperture (which apparently fluctuates in the dark between wide limits). Trouble is also experienced from after-images and ideo-rètinal light in the eye itself, probably produced by the retinal circulation. Values recorded for the minimum energy necessary to produce a sensation of light were found to vary from $7{\cdot}7 \times 10^{-10}$ to $38{\cdot}0 \times 10^{-10}$ in the case of different observers.

SHORT NOTES ON ILLUMINATING ENGINEERING.

AN OXYGEN-FILLED TUNGSTEN LAMP.

According to a recent German patent, beneficial results follow the burning of a tungsten filament in an atmosphere of oxygen at low pressure. This, it is claimed, prevents discharges through chlorine vapours evolved from anti-blackening materials introduced into the bulb. The oxygen at low pressure does not appreciably attack the incandescent tungsten filament, but in the colder regions of the lamp vaporised tungsten is oxidised to tungsten trioxide. The pressure of the oxygen present is, however, extremely low, being less than 0·005 millimetre of mercury.

The small amount of oxygen initially introduced into the lamp would be quickly used up, and the author therefore proposes to include within the bulb certain oxygen-yielding substances, such as the oxides, nitrates, chlorates, &c., of suitable metals. Manganese oxide, in small quantities, is found very beneficial.

CO-OPERATION IN GAS AND ELECTRICITY PRODUCTION.

In his presidential address to the Institution of Gas Engineers, Mr. C. H. Wordingham dealt with the problem, that has come to the fore since the war, of co-operation between gas and electricity undertakings.

"The problems of economy in fuel-use and cheap power production," he said, "are really distinct. While for motive power and lighting, and for certain kinds of furnace work, electricity has a great field of action; there will always be immense opportunities for gas-heating. Gas production should be an intermediary between the raw fuel and the live steam, and so be concerned in the generation of the whole of the electricity used." Mr. Wordingham added that he had for many years advocated the close co-operation, if not the fusion of gas and electric interests, and he believed that appreciation of the soundness of this view was gaining ground.

It is in the national interest to get the maximum useful result in dealing with coal as fuel, and at the same time to extract all the valuable by-products and their derivatives. Here the skill of the chemist and gas engineer come in. The whole of the coal raised should be treated as near to the pit's mouth as practicable, and the useful by-products extracted. At this point the electrical engineer should take up the question of the economical generation and distribution of electricity in bulk.

GAS RATIONING IN HOLLAND.

It appears that Holland, like Denmark, is feeling acutely the present shortage of coal and the consequent difficulties in the production of gas.

The *Gas World*, quoting from a recent letter in the *Daily Telegraph*, describes the experiences of a consumer in that country who has had to shut down the gas fire in the drawing room, as it exceeds the ration ; if this were burned no gas could be used for lighting. Electricity is also rationed, and candles are said to be almost unobtainable. The gas ration for cooking in this case was equivalent to only one cubic foot per day, so that the household has had to practically give up cooking and get its meals from an adjacent emergency kitchen.

OUTSIDE LIGHTING OF CINEMA HALLS BY GAS.

The *Journal of Gaslighting* describes a method of outside lighting by gas which was recently applied by the United Gas Improvement Company to cinematograph frontages in Philadelphia.

The arrangement can be conveniently used with any building equipped with a parapet. Four high-candlepower lamps are spaced at equal distances on hinged brackets supported from the parapet in such manner that they can readily be secured in position in front of the building, or turned round for cleaning or repair. A strong wrought-iron pipe, held firmly by tie-rods, is carried to about three feet above the back of the parapet and a horizontal arm connected by a swing joint carries the lamp. The strain is taken off the hinge, and the lamp locked in position and maintained in place under high wind, by a removable intermediate support that comprises three legs and an adjustable upright, and can be fixed on the parapet. The lighting and extinguishing are both controlled from the manager's office by means of electric current from dry batteries.

The arrangement would be beneficial in enabling powerful lamps to be mounted high up out of the immediate range of vision, and it would, no doubt, be practicable to combine with them a translucent notice in front so as to screen the direct rays, at the same time utilising their light for the purposes of advertisement.

CLASSIFICATION OF ILLUMINATING ENGINEERS FOR WAR SERVICE.

We understand that the Illuminating Engineering Society in the United States, in common with other bodies in that country, is making out a classification of its members with a view to their employment for war work in positions where their special knowledge will be of service.

It is hoped that this step will be useful in assisting the authorities to put the square peg in the square hole.

RESTRICTION OF SIGN LIGHTING IN THE UNITED STATES.

We observed that an Order issued by the United States Government in November prohibits the lighting of outdoor signs and other forms of electrical display until 7.45 p.m. at night. This Order is intended to bring about a saving in coal required for producing electrical energy, and appears to eliminate the use of illuminated signs over the peak period. The total amount of power so used in the States is estimated to be equivalent to the use of 250,000 tons of coal per annum, and it is calculated that the new measure will save 50 per cent. of the power at present employed for electrical display.

This is a moderate restriction, and it is evident that the authorities have designed it to enable a period of adjustment to the new conditions to take place.

THE SEPARATION OF VISIBLE AND INVISIBLE LIGHT.

In the *General Electric Review*, W. S. Andrews describes a simple apparatus for the separation of visible and invisible light. The rays from a small source of light are concentrated by a quartz lens. The focal point for visible rays is then at a different distance from the lens than in the case of visible light. Accordingly, if a pin-hole is placed at the non-visible light focus, the luminous rays will be largely intercepted by the diaphragm.

The apparatus will prove very useful for studying the fluorescence of willemite and similar substances under the light from an iron spark. If some such separator is not used the fluorescence of many materials is apt to be masked by the large percentage of visible light striking the specimen.

THE SHORTAGE OF ELECTRIC LAMPS IN THE UNITED STATES.

Another indication of the effect of the war in the United States is furnished by the reports of a shortage of electric incandescent lamps in certain localities.

According to an inquiry by the *Electrical World*, there is at present no valid reason for such a shortage, unless it is due to transport difficulties. In any case it is anticipated that it will only be temporary.

It is possible, however, that the acute demands for Army cantonments and Navy bases may have produced an apparent shortage in the 25, 40, 50 and 60-watt types.

In one direction, automobile lamps, there is an admitted shortage chiefly owing to the abnormal increase in the demand.

COAL SHORTAGE AND ITS EFFECT ON U.S.A. GAS PRODUCTION.

We notice that increased demands for gas production, coupled with difficulties in getting sufficient coal, are now causing inconvenience to gas companies in the States. In that country, as in England, new demands for gas in war industries have sprung up. In some cases the effect of scarcity of coal on the householder has also been the cause of trouble. The Indianapolis Company, for example, finds that many consumers are using gas instead of coal for house heating, and in some cases have even used the gas-range for heating purposes.

Evidently there, as here, the situation calls for economy on the part of the consumer, and the avoidance of all wasteful methods of using gas, either for heating, cooking, or lighting.

CARBONS FOR CINEMATOGRAPH WORK.

According to a recent patent (No. 1,241,740) taken out in the United States, the correct proportions between diameters of positive and negative electrodes has an important influence on the steadiness of arcs used for cinematograph work. The patent states that by using a ratio of 4:1, and by an improvement in the copper-plating of the negative carbon holder, all flickering and sputtering can be avoided. With a single copper covering beads of molten copper are apt to form in the crater, causing undesirable flicker, and sometimes leading to the projection of copper particles on to the lens. It is claimed that this effect can be eliminated completely by using a second coating of nickel.

LIGHTING LARGE ROOMS WITH PEDESTAL FITTINGS.

In this country the use of pedestal fittings to produce indirect lighting is not well known, though it has been effectively employed in a number of cases in the United States.

In the *Electrical World* the use of this system at the South Shore County Club in Chicago is described. In this club there are two garden foyers in which an attempt was made to simulate daylight illumination. Each room measures 36 ft. by 72 ft. The high arched ceilings are tinted a pale blue and the light is all supplied from a 7 ft. pedestal which contains two 500-watt gas-filled tungsten lamps with silvered reflectors. The absence of harsh shadows and glare is stated to be an agreeable feature.

Another room measuring 435 ft. square is lighted in a similar manner from a 10 ft. central pedestal unit containing five 500-watt gas-filled tungsten lamps.

LIGHTING IN LONDON AND THE PROVINCES.

Arrangements have been made at Walsall, says *Municipal Engineering*, for about 200 additional gas lamps to be lighted in the streets. The matter has been under consideration for some time, and it is thought that the public will appreciate this concession in view of the great danger that has existed owing to the darkened state of the streets. The lights can be extinguished in case of emergency.

The same journal states that the Pontypridd (Wales) Urban District Council consider that the local lighting required improvement. At a recent meeting of the Gasworks Committee of the Council the Chairman suggested that they should follow the example of Carmarthenshire, and light more lamps and it was decided to apply for the removal of the restrictions.

We notice references to this matter in other journals. For example, *Electricity* recently summarised steps being taken to improve the lighting in Bath, Birmingham, and Worksop, the latter, it is stated, to be lighted "as in normal times!" On the other hand, at Brancaster, in Norfolk, it was reported that the only oil lamp in the village should, during the winter months, be turned on "half full," the estimated saving being 2s. 9d.!

The action of the Wellington Urban Council, the Chairman of which announced that arrangements had been made for several members to inspect several streets where the lights had been recently shaded, is mentioned with approval. Cases are on record in which lamps have been extinguished without inspection, where they might very well have been allowed to remain lighted, and *vice versa*.

The lighting conditions in many provincial towns certainly seem to call for more careful consideration, with a view to agreement on some general principles in war time lighting. In London the present arrangements might with advantage be carried out in a more uniform manner, while still complying with the requirements of the Commissioner of Police, acting on the advice of the Field-Marshal Commander-in-Chief of the Home Forces. In the Provinces the methods adopted in different towns seem to differ still more widely.

THE REFLECTING POWER OF TUNGSTEN AND ITS EFFECT ON LAMP-EFFICIENCY.

A recent investigation undertaken by W. W. Coblentz and W. B. Emerson, at the Bureau of Standards, describes some tests on the reflectivity of tungsten in the infra-red. The experiments were made on plane polished mirrors, the reflecting power of which was compared with that of silver by a new method involving the use of a total reflection prism. With pure tungsten there is a marked indentation at 0·8 μ and 1·3 μ, but the latter does not occur with the impure metal. The reflectivity of tungsten rises abruptly from 50 per cent. at 0·5 μ to 90 per cent at 2 μ beyond which the reflectivity gradually increases to about 96 per cent at 6 μ.

The bands of selective absorption at 0·8 μ and 1·3 μ render tungsten conspicuous as being the only pure metal thus far investigated, which has bands of selective reflection in the infra-red. This property is intimately associated with the high efficiency of the metal for the emission of light. If one could discover a metal characterised by almost complete suppression in infra-red reflection, the result would presumably be a great gain in luminous efficiency.

TOPICAL AND INDUSTRIAL SECTION.

[At the request of many of our readers we have extended the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]

B.T.-H. WIRING SUPPLIES.

We have received a copy of a recent and well-prepared list from the Lamp & Wiring Supplies Dept. of the British Thomson-Houston Co., Ltd. This list, which extends to over 70 pages, relates entirely to wiring installation accessories, including wiring appliances, such as lampholders, switches, wall plugs, ceiling roses, cut-outs, distribution boards, fuse boxes, wood blocks, insulators, etc., etc.

This list is well adapted to the convenience of the buyer, being divided into five sections, each of which deals with a particular type of accessories. Each page is divided into two halves, the outer half being given to the illustrations and the inner half containing the listing and description of the devices. It has not been possible to include prices in this list, owing to the price fluctuations in this class of material under war conditions, but the B.T.-H. Co. issue regular quotations on this material each month.

There are several lines of accessories of particular interest in this new list, which we briefly refer to as follows :—

A new line of porcelain type Goliath Edison screw lampholders designed after careful study of the requirements of the Admiralty and other Government Departments.

Also new substantial designs of brass-cased Goliath holders. The quality of these holders will recommend them to all purchasers who desire a well-finished, substantial type of holder.

There are also listed excellent lines of standard bayonet and Edison screw holders, in both porcelain and brass case types.

Ceiling roses. Attention is particularly called to the well-known B.T.-H. "Quiklok" cover ceiling rose. This rose has been approved and standardised by the War Office, and has many points of advantage over the ordinary ceiling rose, the chief of which is that it can be wired on the bench and secured in position on the ceiling by a quarter turn of the wrist.

The well-known B.T.-H. interlocking switchplug is listed, in conjunction with numerous other types of combination switchplugs.

A line of new pattern distribution fuse boards is included, and a new range of insulators.

Copies of this list have been sent to all holders of the handbook issued by the L. & W.S. Department of the B.T.-H. Co. Extra copies can be obtained on application to the Company at Mazda House 77, Upper Thames Street, E.C.4.

STUDENT CAPTIVES.

We have received some further particulars of the work of the British Prisoners of War Book Scheme, which is under the direction of Mr. A. T. Davis of the Board of Education.

The booklet (No. 11) contains a letter of appreciation from the Prime Minister, and a general communication addressed to Mr. H. A. L. Fisher and signed by a large number of leading educationists and social workers expressing their sense of the great national value of this work. An introduction by Professor Gilbert Murray refers to the chief features of the scheme in fuller detail, and extracts from letters of captives at Ruhleben, Minden, Döberitz and other well-known camps testify to their gratitude for the educational matter received.

Under this scheme educational works can be forwarded to prisoners' camps, enabling them to carry on study in captivity, and thus alleviate the monotony and dreariness of their position. Readers can help by sending to Mr. A. T. Davis at the Victoria and Albert Museum, London, S.W.7, gifts of money or books. There could hardly be a better cause. The scheme should appeal with special force to scientific and technical men who can appreciate what a deprivation it must be to be cut off by captivity from all mental contact with the outside world.

"SUN NEWS"—A BULLETIN ON LIGHTING FROM JAPAN.

The Osaka Electric Lamp Co., in Japan, send us some specimen copies of a small illustrated booklet entitled *Sun News*, dealing with illumination. The text is entirely in Japanese, and the majority of the illustrations seem to refer to installations in Japanese cities. So far as one can judge most of these are carried out on lines familiar to Western nations. There are electric signs executed in Japanese characters, festoons of small lamps for lighting public gardens, and several instances of flood-lighting with batteries of searchlamps.

On the other hand we also notice an instance of special street lighting with glow lamps in typical Japanese lanterns, which follows more closely the traditional Eastern ideas on illumination.

INSTRUCTION IN ELECTRIC LIGHT SWITCHING.

Messrs. A. P. Lundberg and Sons send us a copy of a booklet, arranged by Mr. W. Perren Maycock and entitled *A First Course in Electric Light Switching and Testing*. The course is a simple preliminary one for junior technical classes and private students, and does not require elaborate tools or apparatus. It consists of a series of 17 exercises, accompanied by a list of apparatus required for 10—20 students. The author also provides some hints on working out electric circuit problems. It is hoped that the courses will be helpful to teachers of wiring classes, who are often restricted to a limited amount of material.

Assets exceed £2,500,000.

Claims paid over £8,500,000.

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GENERAL

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WAR ECONOMY.

In consequence of the War, the cost of building material and labour has increased nearly 50 per cent. All owners of property should therefore increase their Fire Insurances; this they can do at little or no extra cost by taking a Fire Bonus Policy with this Corporation, and thus effect a saving of 20 per cent. of each premium.

Particulars on receipt of post card at either of the above Offices.

F. NORIE-MILLER, J.P.
General Manager.

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No person can recover under more than one Coupon Ticket in respect of the same risk.

Signature ....

This Coupon must not be cut out but left intact in THE ILLUMINATING ENGINEER as that being dated, forms the only evidence of its currency.

THE PRODUCTION OF DUCTILE TUNGSTEN.

We understand that in a recent account of Mr. Sydney Johnstone's lecture on "The Rarer Key Metals," to which reference was made in our last issue, it was stated that the manufacture of ductile tungsten for incandescent electric lamps was not carried on in this country before the war.

We are informed by the British Thomson-Houston Co., Ltd., that they were supplying their whole requirements of ductile tungsten for Mazda lamp filaments in 1912 by manufacture at their Rugby works. At that time, and until within a month or two from the date of the outbreak of war, the raw material used was tungsten oxide, but the Company, foreseeing a possible shortage of that material, immediately started the manufacture of the metal from the raw ore, which is of British origin. The whole process of refining the ore, and producing ductile tungsten filaments from the metal obtained, has now been continuously in operation since the middle of 1915, and it is stated that many millions of feet of wire have been made.

THE HOLOPHANE HEADLIGHT LENS.

In view of the discussion that has been taking place in the United States on the design of headlights, to which reference was made in our last number, it is of interest to mention a development in this direction, of which we have received particulars from Holophane Ltd. It is well known that State Laws and City Ordinances differ widely in their requirements. As an example we reproduce the requirements of the State of Connecticut, from whom the Holophane Lens Headlight has received an approving certificate. The legal requirements imposed are as follows:—

(1) "That no portion of the beam of reflected light, when measured 75 feet or more ahead of the lamps shall rise above 42″ from the level surface on which the vehicle stands."

(2) "Sufficient light to discern a person or substantial object 150 (250) feet directly ahead of the vehicle."

(3) "Sufficient side illumination to reveal any person, vehicle or substantial object 10 feet to both sides of a vehicle, at a point 10 feet ahead of lamps."

The Holophane device achieves these objects by a special division of the glass surface into specific areas, each having the appropriate specially designed prisms. The prisms in the upper portion serve to deflect and spread the top of the beam towards the horizontal: below this there is a diffusing projecting fin to prevent glare by shielding the filament: and below this a central area in which the lenses are shaped to illuminate the sides of the road and the road-surface near the car.

The third and lower part of the glass area consists of concentric prisms designed to spread the beam on the more distant parts of the road. The design of the projecting anti-glare fin, in particular, calls for special care.

The whole arrangement appears to offer an excellent example of the scientific control of rays of light and doubtless more will be heard of it when the present restrictions are somewhat relaxed.

ELECTRICITY · ACETYLENE · OIL · GAS

The
ILLUMINATING
ENGINEER

Edited by
LEON GASTER

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EDITORIAL.

Mr. Trotter's Presidential Address to The Illuminating Engineering Society.

On pp. 309-320 in this issue we reproduce Mr. Trotter's Presidential Address before the Illuminating Engineering Society on December 18th. It is just eight years since the late Professor Silvanus P. Thompson delivered his Inaugural Address, in which the field of work of the Society was ably summarised. Mr. Trotter's address forms a useful supplement to that presented by our first President. He deals in a characteristically lucid manner with the field of illuminating engineering as it now presents itself and the humour and irony occasionally revealed only serve to emphasise the enthusiasm that Mr. Trotter brings to bear upon his subject. The President, as all our readers know, was one of the earliest pioneers in the scientific study of illumination. His classic paper before the Institution of Civil Engineers in 1892 is rightly recorded as one of the first clear expositions of the distinction between the light yielded by a source, and its application, as illumination, to the practical problems of life. It is interesting to recall that Mr. Trotter presided at a meeting held at the Association of Engineers in Charge in 1907, when the project of forming an Illuminating

Engineering Society was first publicly introduced by the writer. It is our earnest hope that the Society will continue to benefit from his skill and experience for many years to come.

In the earlier portion of the address Mr. Trotter discusses the work of the Society, pointing out several respects in which it differs from many other bodies. While its field is essentially scientific it has a special function in uniting men engaged in different professions or concerned with various aspects of illumination ; not only do experts of various kinds find a common platform for the discussion of topics of common interest, but the co-operation of members of the general public, who are concerned with the uses of illumination rather than its technical aspects, is also sought. Passing on to the measurement of illumination, Mr. Trotter points out that, while essential to scientific study, they must be interpreted in relation to the impressions received by the eye, in accordance with the precept of Lambert, *solus oculus est judex*. The subject has also its historical side, and in forming our modern conceptions of the nomenclature of illuminating engineering, we can doubtless learn something, not only from early scientific workers like Lambert, but even from the ideas on the nature of light entertained by the ancient Greeks.

In the latter part of the address Mr. Trotter makes some illuminating references to current problems, such as the darkening of the streets. He gives an account, necessarily in very general terms, of a balloon trip undertaken for the authorities over London by night, in which the appearance of the shaded lights was observed. Mr. Trotter now voices what we believe may be regarded as the official view, that it is impracticable, by any method of screening the lights, to conceal completely a large city like London. The provision of a uniform illumination, and the avoidance of marked contrasts in brightness, appear to be the best form of camouflage. On the other hand, in the case of small towns and villages, particularly those on the coast, complete extinction of lights may be justified, and may be effective in concealing the neighbourhood and misleading hostile aircraft as to their position. In the future, therefore, it would be desirable to contrive means of diminishing or extinguishing the lights immediately the danger signal is received. If these points are borne in mind, and the inevitable effect on traffic in busy streets of extreme diminution in light is considered, the desirability of modifications such as those introduced by the authorities at the beginning of the present year will be appreciated. All of us fully recognise the necessity of meeting the requirements of the authorities on such points, and we have no doubt that in cases where experts like Mr. Trotter have been consulted the results have been beneficial. Our only regret is that the services of such experts were not more fully utilised at an early stage in the war, and that even at the present time they are not employed to the extent that seems desirable.

Mr. Trotter also refers to the work of the committees assisting the authorities, by experiments on flares, star-shells, parachute lights, and luminous paints used for gun-sights, and other purposes—facts which are now mentioned publicly, with the sanction of the authorities, for the first time. These special researches offer one interesting illustration of the many ramifications of illuminating engineering, and the opportunities for its application in war work at the present moment. They are instances of the fact remarked upon in our last number. Even the present circumstances have only served to divert, but not to check, the stream of investigation and research in the fascinating field of illumination.

Electric Power Supply in Great Britain.*

The Report recently issued by the Coal Conservation Sub-Committee of the Reconstruction Committee on the above subject will excite great general interest. In the introduction to the Report the Committee state that " it is scarcely possible to exaggerate the national importance of the problem of a technically sound system of electrical supply because it is essentially one with the problem of the industrial development of the country, which largely depends upon increasing the net output per head of the workers employed in the industries in which power can be used." A second important consideration is the economy in the use of coal which such a system may be expected to bring about.

That the present arrangements for electrical supply can hardly be described as " technically sound " will be generally conceded. They have developed individually according to the needs of each district, and have not been schemed out on any ordered plan. Electric supply is undertaken by over 600 authorities in as many separate districts, while in Greater London alone there are 70 supply authorities, with the additional disadvantage that the system of supply and the voltage vary according to the district served.

Small generating stations are admittedly uneconomical. It is therefore recommended that large super-plants should be established at suitable centres, where coal and water are available, and feeding into a main trunk distribution system laid down throughout the country. For this purpose the country should be divided into some 16 districts, throughout each of which there should be a standard periodicity and trunk main voltage.

It is estimated that the adoption of such a scheme would, in the near future, result in a saving of about 57,000,000 tons of coal per annum, and that this saving, if applied to the production of power, would make it possible to generate an additional 15,000,000 h.p. According to the figures presented in the Report, the output of coal in the United Kingdom in 1914 was 287,430,473 tons, on which 189,092,369 tons were reserved for home consumption. The estimated saving thus amounts to nearly 30 per cent.

Consideration of the probable future development of British industries shows, however, that it is not so much by reducing our total coal consumption as by increasing our industrial output for a given coal consumption that progress will be made. The effect of the scheme upon industry and transport would be very considerable. The amount of power used in the United States per worker is estimated at 56 per cent. more than in the United Kingdom, while, if we eliminate trades in which the use of power is not convenient, and restrict ourselves to those where it *can* be used in large quantities, we should probably find that the power used per worker in the States is double what it is here.

The development of adequate electric power supply would do much to remedy this deficiency, and to make possible the starting of many industries which are dependent on an abundant supply of cheap electrical power, and have hitherto been undertaken mainly abroad.

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* Interim Report on Electric Power Supply in Great Britain, presented by the Coal Conservation Sub-Committee of the Reconstruction Committee of the Ministry of Reconstruction, Cd. 8880, 3d. net., published by H.M. Stationery Office, Imperial House, Kingsway, London, W.C 2.

While the Report naturally lays stress mainly on the question of the use of electric power in industry, and the conservation of our coal supplies, it should not be overlooked that the advantages of such a system of supply upon lighting would be equally great. With the better facilities for producing power, and the equalisation of load throughout the country, the cost of electric lighting should ultimately be considerably reduced, and it should also be possible to do away with, or at least considerably improve. the highly complex and varied systems of charging at present in vogue. The great advantage to the lamp industry of a standard voltage should also be borne in mind. Lamps would be greatly improved and prices reduced by standardisation in manufacture. The great variety of pressures prevailing at present is admittedly a drawback, since it interferes considerably with standardisation. From the consumer's standpoint it is likewise inconvenient, especially in the case of Government Departments and industrial concerns, which have branches in different districts, and must therefore order lamps of a special voltage for each. When a factory is transferred from one district to another, it may be found that all the existing lamps, motors, &c., cannot be used, owing to the difference in the pressure or system of supply.

On the other hand, we imagine that an absolutely uniform voltage throughout the country would also not be quite convenient to makers of electric lamps, for it is desirable to allow a small margin for variation in manufacture, so that lamps inadvertently made to work at too high an efficiency can be transferred to a district with a lower voltage, or *vice versa*.

In their concluding remarks, the Committee recommend the appointment of a Board of Electricity Commissioners, with full powers to deal with the electric supply situation throughout the country, the sites for the central generating stations to be selected at once and plans prepared for the construction of the necessary plant immediately after the war. In an Appendix several alternative schemes for taking over the existing concerns are presented, and suggestions are made on the question of public or joint ownership of local electric concerns. No doubt the various super-generating stations will be added by degrees, and there will therefore be ample opportunity to take advantage of any important new developments. The linking up of such stations in industrial areas will have the advantage that they can assist each other in the event of local overload or destruction by hostile action.

Finally, while we recognise that this is probably a matter outside the scope of the Committee's terms of reference, we think that the very important question of co-operation with the gas industry should not be overlooked. In his recent presidential address before the Institution of Electrical Engineers Mr. C. H. Wordingham emphasised the desirability of co-operation of this kind, adding that gas production should be an essential intermediary between the raw fuel and the live steam. The problem of electric power production is a vast one, but the supply of gas throughout the country is equally vital. In selecting the sites for the generating stations, therefore, and in the choice of plant, the possibility of working hand in hand with those concerned with the supply of gas, and the production of its valuable by-products should be carefully considered. It is essential to get the maximum value out of the coal, whether in the form of electricity, gas or the derivatives which will no doubt play a vastly more important part in the gas industry of the future.

LEON GASTER.

TRANSACTIONS

OF

The Illuminating Engineering Society.

(Founded in London, 1909.)

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

FIRST MEETING OF THE NINTH SESSION.

(Proceedings at the Meeting of the Society held at the House of the Royal Society of Arts, 18, John Street, Adelphi, W., at 5 p.m. on Tuesday, December 18th, 1917.)

A MEETING of the Society took place as stated above on Tuesday, December 18th, the PRESIDENT (Mr. A. P. Trotter) being in the Chair.

The Minutes of the last meeting having been taken as read, the HON. SECRETARY read out the following names of applicants for membership:—

Captain A. C. TRENCH, R.E., Oatlands, Simla.
Mr. JAMES LOWE, Engineer to the Carlton and Ritz Hotels.

The names of applicants for membership read at previous meetings on February 20th and May 15th* were also read again, and these gentlemen were formally declared members of the Society.

The HON. SECRETARY then presented the customary account of events during the vacation (pp. 307-308), in which he referred to the loss the Society had sustained in the death of Mr. W. DUDDELL, and announced that in accordance with the arrangements entered into with the Institutions of Gas and Electrical Engineers, the Acting Presidents of these two institutions, Lord MOULTON and Mr. C. H. WORDINGHAM, had been nominated Vice-Presidents and Members of Council of the Society during their tenure of office Dr. CHARLES CARPENTER had also been nominated a Vice-President and had kindly consented to act on the Joint Committee on Illuminating Engineering under the Department of Scientific and Industrial Research.

Reference was made to the work of this committee, to the investigations being undertaken by the special committees carrying out experimental work for the Ministry of Munitions, and the participation of the Society in the work of the Safety-First Council.

The Hon. Secretary also mentioned several important movements such as those bearing on Industrial Reconstruction and the Organisation of Engineering Training which would be considered in relation to the work of the Society.

Mr. A. P. TROTTER then delivered his Presidential Address (see pp. 309-319), in the course of which he gave a masterly survey of the work of the Society, illustrating the very varied nature of the subjects which fell within its scope. He pointed out that the study of illumination, besides being experimental, had its philosophical side, and that measurements of illumination must be interpreted in relation to the effect of light on the eye.

The President next touched on a number of matters that had been the subject of discussion before the Society, such as Street Lighting, Nomenclature and Units, and Standards of Light, in connection with which the Society had found it desirable to co-operate with cognate institutions. Reference was made to the recently appointed Joint Committee on Illuminating Engineering, under the Department of Scientific and Industrial Research.

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* *Illum. Eng.*, Feb. 1917, p. 39; April 1917, p. 101.

Turning to matters of special topical interest, the PRESIDENT remarked that the methods of street-darkening were of great interest to the Society, and gave a brief but very instructive account of some of his investigations on this point.

Reference was also made to several special investigations which the Society was undertaking for the authorities, such as tests on star-shells, flares and parachute lights, for which a special photometer had been designed. At the same time investigations were being made on the luminous radio-active paints employed for gun-sights and other special purposes.

Finally, the President referred to some of the chief physiological aspects of illumination, and concluded by expressing his conviction that a great field of usefulness lay open to the Society in the future.

Mr. F. W. GOODENOUGH (Chairman of Council) proposed a vote of thanks to Mr. Trotter for his address, and said that the Society must congratulate itself on having for its President one who had such a long and distinguished relation to illumination, and had done so much pioneering work in this subject. His address had been a masterly survey of the work of the Society, and they must all recognise how wide was the field covered therein. The need for closer relations between science and industry was now widely recognised, and the Illuminating Engineering Society was peculiarly fitted to promote this connection within its own field of work. It gave him great pleasure to propose the vote of thanks to Mr. Trotter, and he felt sure that the Society would prosper under his presidency.

Lieut.-Commander HAYDN T. HARRISON, who seconded the vote of thanks, said that he had long looked forward to the time when Mr. Trotter would assume the Presidency. He regarded Mr. Trotter's well-known paper before the Institution of Civil Engineers in 1892 as one of the first to emphasise the scientific side of illumination, and to draw the distinction between the emission of light at the source, and the resultant effect in the form of illumination.

Mr. Trotter had been honourably connected with much of the early pioneering work on the measurement of illumination, and in his Address he had remarked on the necessity for interpreting photometric results in relation to the impressions received by the eye. At the same time, they all knew that the eye was a most easily deceived organ, and required the aid of the photometer to correct its judgments. He was very glad to associate himself with Mr. Goodenough in proposing a vote of thanks to Mr. Trotter for his address.

Mr. GOODENOUGH having been called away at this point, the vote of thanks was moved by the HON. SECRETARY, who recalled that it was just ten years ago that the preliminary meeting was held at the Association of Engineers-in-Charge, at which the conception of illuminating engineering was first publicly discussed in this country, and the proposition to form an illuminating engineering society was made. In the absence of Sir William Preece Mr. Trotter had kindly consented to preside at that meeting, and then and afterwards gave him every encouragement. He hoped that the Society would continue to benefit by his knowledge and experience for many years to come.

The PRESIDENT, in acknowledging the vote of thanks, said that he would not have felt able to accept the position of president without the knowledge that he had the support of their enthusiastic Hon. Secretary and his assistant, Mr. Dow.

It was announced that the **next meeting** would take place at **5 p.m. on Tuesday, January 15th, 1918,** when a paper would be read by **Mr. L. Gaster** on "**Ten Years of Illuminating Engineering: Its Lessons and Future Prospects.**"

NOTES ON EVENTS DURING THE VACATION.

By L. GASTER, *Hon Secretary*

(Presented at a meeting of the Society held at the House of the Royal Society of Arts, 18, John Street, Adelphi, W., at 5 p.m. on Tuesday, Dec. 18th, 1917.)

IT is customary, at the first meeting of the session to give some account of progress during the vacation.

In accordance with the arrangement entered into with the Institutions of Gas and Electrical Engineers, the Presidents of these two institutions, namely, Lord Moulton and Mr. C. H. Wordingham, have kindly consented to become Vice-Presidents and Members of Council during their tenure of office. The Council had also nominated Dr. Charles Carpenter, who had kindly consented to act on the Joint Committee on Illuminating Engineering under the Department of Scientific and Industrial Research, a Vice-President of the Society. By the death of Mr. William Duddell, on November 4th, the Society has lost one of its distinguished Vice-Presidents. While chiefly known for his brilliant achievements in various branches of electrical technology Mr. Duddell took a keen interest in lighting, and, following the death of Mr. Edward Allen in 1915, became President of the National Illumination Commission in this country. In his early death science has lost one of its most brilliant representatives.

Among the younger members of the Society who have fallen in the war we note the name of Corporal Anderson, formerly associated with the Lancashire Electric Power Company.

Although no meetings are held during vacations, and in the present circumstances international gatherings to discuss lighting matters are naturally impracticable, the Society has nevertheless not been inactive during the last few months.

The Joint Committee working under the Department of Scientific and Industrial Research, and the special committees undertaking experimental work for the Ministry of Munitions, have been continuing their researches. In addition, suggestions have been submitted for the consideration of the authorities on such matters as economy in lighting in relation to fuel supply, lighting arrangements in connection with air-raid shelters, the desirability of obtaining fuller information and statistics relating to the effect of inadequate illumination in causing street accidents, and other matters.

Through its representatives the Society has also been participating in the work of the London Safety First Council, especially in regard to the relations between illumination and street safety. The programme of the Safety First Council has recently been extended to apply to industrial matters, and this will doubtless afford opportunities for further educational work regarding the importance of proper lighting of factories.

In another matter of public importance, the lighting conditions of cinema halls, the Society has also been consulted. It will be recalled that in a paper read by Dr. James Kerr before the Society on February 20th in the present year on "The Effect on the Eye of Varying Degrees of Brightness and Contrast," special reference was made to the lighting of cinema halls, as exemplifying very clearly the importance of avoiding glare and undue contrast. The attention of the Cinema Commission of Enquiry, a joint commission carrying on an investigation into the cinematograph industry generally, was drawn to this discussion, and two members of the Commission were present. An invitation was conveyed by them to the Society to co-operate with the Commission in regard to matters of lighting, and the hon. secretary subsequently gave evidence pointing out various defects in lighting that needed to be guarded against, and suggesting the formation of a small joint committee to make further inquiries.

The members of the Commission in their Report recently issued,* endorsed the chief suggestions made and recommend the formation of a joint committee on the lines proposed. It is hoped that this suggestion will shortly be carried into effect and arrangements made for photometric tests of the illumination in a series of typical halls. In view of the influential and representative character of the Commission the Report will no doubt receive sympathetic consideration from the Authorities.

In view of the general recognition of the need for better organisation and extension of the nation's facilities for technical education it is interesting to observe that an important step has recently been taken in regard to technical optics. A special department of Glass Technology was established not long ago at Sheffield University, and the matter has likewise been receiving the attention of the Conjoint Board of Scientific Societies. In the recently issued Annual Report of this body reference is made to the formation of an Advisory and Administrative Committee, under the ægis of the Imperial College, on National Instruction in Technical Optics. Mr. F. J. Cheshire has been appointed Director of Studies in Technical Optics. It has been represented that such matters as photometry, the manufacture and testing of illuminating glassware, etc., should receive consideration in a complete scheme of Technical Optics, and the Director has kindly promised to bear this matter in mind.

It is also of interest to mention several matters which have been the subject of discussion in connection with industry and technical education generally, such as the proposals being made on Industrial Reconstruction and the Organisation of Engineering Training, which will receive due consideration in their relation to the work of our Society.

Turning next to activities in connection with illumination in other parts of the world we learn that the formation of an Illuminating Engineering Society is contemplated in Japan and preliminary steps have been taken to express the cordial desire for co-operation with our own Society. It is also stated that the Electrotechnical Section of the Russian Technical Society is forming a Standing Committee on Illumination, in which members of various scientific and technical societies will take part.

In the United States the usual Annual Convention has been cancelled on account of the war, but arrangements have been made for the circulation of papers and their discussion by correspondence. The series of lectures arranged by the Council of the American Illuminating Engineering Society on "Illuminating Engineering Practice," for delivery at the University of Pennsylvania, has been issued in volume form.

With the entry of the United States into the War the Illuminating Engineering Society in that country has been afforded several opportunities of rendering useful service to the Government. A National Committee on Lighting has been appointed by Mr. Samuel Gompers, Chairman of the Committee on Labour, of the Advisory Commission of the Council of National Defence. It will deal generally with the lighting of all factories, mills, munition plants, arsenals, etc., engaged on war work, from the standpoints of preservation of health, diminution of accidents, improved quality and output of work, and protection of property and persons.

Three new committees have also beed formed by the Society in the Uniten States to deal with (*a*) problems in the illumination of aviation cantonments, (*b*) standardizing lighting practice in industrial establishments, and (*c*) investigation on problems of visibility at sea.

The opportunities thus afforded to the American Illuminating Engineering Society to utilise the special knowledge of its members in connection with the war marks an important precedent which should be borne in mind by the authorities in this country.

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* *Illum. Eng.*, September, 1917, pp. 233, 234.

ALEXANDER PELHAM TROTTER,

PRESIDENT OF

The Illuminating Engineering Society

(Founded in London 1909).

IT is with great pleasure that we record the acceptance of the Presidency of the Society by Mr. ALEXANDER PELHAM TROTTER, in succession to Sir William Bennett.

Born in 1857, educated at Harrow and at Cambridge under Clerk Maxwell, and trained as a mechanical engineer, he is now a partner in the firm of Handcock, Dykes and Trotter, Consulting Engineers, Westminster.

Mr. TROTTER has subsequently had a long and honourable connection with ILLUMINATING ENGINEERING. In association with Sir William Preece he was responsible for much pioneering work in illumination-photometry, and his early researches on prismatic illuminating glassware were equally in advance of the times.

He has been prominently identified with the work of the Society since its foundation, participating in the Joint Committees on School and Library Lighting, and on the Standard Specification for Street Lighting. He is Vice-Chairman of the National Illumination Commission.

Since the outbreak of war Mr. TROTTER has presided over a Committee of the Society, undertaking special experimental work for the Ministry of Munitions, and is also the Chairman of the Joint Committee on Illuminating Engineering, appointed under the Department of Scientific and Industrial Research.

The portrait of Mr. TROTTER on the reverse page represents him as Private 2474, C Company, Vth Battalion of the National Guard City of London Volunteer Regiment.

A. P. TROTTER

President of

The Illuminating Engineering Society

(Founded in London, 1909)

(As a private in the National Guard)

ADDRESS

By A. P. TROTTER, President.

(Address delivered at the meeting of the Society held at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, W., at 5 p.m. on Tuesday, December 18th, 1917.)

It sometimes happens that a man is called upon to undertake responsibilities in matters which have for many years been one of the relaxations from his daily work, to attempt a broad survey of a field in which hitherto his attention has been directed only where it has been attracted, and to treat seriously a subject which has been a hobby.

The Illuminating Engineer.

The name of the Society which has honoured me by electing me as its President was wisely chosen nine years ago. It is not the Society of Illuminating Engineers. At that time it is doubtful whether anybody was entitled to be called an illuminating engineer. To-day, an astonishing number of considerations must be studied by one who undertakes to give competent and impartial advice on the most appropriate and economical type of lighting for any given case, on the selection between electric light, gas, oil, or candles; whether the supply should be taken from the public mains or generated by a private plant; whether the gas to be used should be coal gas, petrol-air gas, or acetylene. And a yet more experienced man must be found who would claim to be able to carry out in detail the lighting of a palace, a railway terminus, a clothing factory, and a coal mine, in the best possible manner. Of these, the palace would perhaps be the most easy. We are proud to have such men amongst our members.

On a stocktaking occasion such as this, we may consider the general object of scientific societies, in order to see what we are doing, what we ought to do, and how we stand. In 1831 the British Association for the Advancement of Science was founded. At that date it is likely that science was not advancing as rapidly as might be, and the Association has to some extent achieved its purpose. But in the first decade of this century, and up to the outbreak of war, science was progressing by such leaps and bounds that some association or other agent appeared to be needed to stem the torrent of its advance. Even the war has but emptied college laboratories and diverted the attention of a very limited number of favoured men who have been permitted to apply their scientific knowledge and experience to naval and military operations.

The output of scientific work flows through four main channels, namely, the journals of scientific societies, the publication of books, the technical Press, and the work done in the private laboratories of manufacturers, which, if divulged at all, is published only through the Patent Office. Besides these, there is a rivulet of scientific work done for the love of it by men who do not care to write or to submit their writings to criticism.

The object of most scientific societies is the publication of the original work of its members and provision for discussion. In some cases, as at the Royal Institution, the communications are chiefly oral, and there is no discussion. At the older engineering institutions papers are written by specialists on subjects which they have made their own; these are submitted to the criticism of referees and of committees before acceptance, and are followed by discussions extending sometimes over several evenings. These papers and the reports of the discussions form the contents of Journals or Proceedings or Transactions. In some cases, as, for example, at the Royal Society, the papers are actively discussed, but no report of the discussion is ever published. In our Society we have often arranged for discussions without exacting heavy work from the authors of papers. A very few terse statements are sufficient to provoke a good debate if the subject be well chosen. Where a scientific society can afford to print the papers in full, with their illustrations or diagrams, and to circulate copies several days before the meeting to members and visitors who are likely to contribute valuable remarks, a brief abstract is all that need be read, and to read the paper in full is a waste of time.

The multiplication of scientific societies is sometimes regretted, especially by older men. There were some 120 scientific and technical bodies before the war connected with engineering and various branches of physical science. Very few of these have been wound up, though some may be dormant. About 70 of these are societies at which papers are read and discussed; some 30 or so are associations of groups of men having some common interests in their professions or trades; and besides these there are social clubs and benevolent institutions. Excellent scientific work has been done, work that could not in any other way have been performed, by such comparatively small bodies as the Faraday, the Röntgen, and the Wireless Societies. These study the application of certain branches of physical science to a narrow subject or group of subjects. They ramify into particular lines of an exclusive character. The Institution of Civil Engineers, though not the oldest, is the premier body, and there are few branches of engineering to which it would not extend its dignified patronage. In 1892 it honoured that one for which our Society is founded by awarding its Telford Medal and Telford Premium to a paper on "The Distribution and Measurement of Illumination." A paper on illumination, whether theoretical or practical, read before one of the older engineering societies, would be addressed to an audience having more or less specialised interests. For example, that of Mr. Henry Fowler on "Lighting of Railway Premises," read before the Institution of Mechanical Engineers in 1906, or the paper by Lieut.-Commander Haydn Harrison on "Street Lighting," and the one by Messrs. S. L. Pearce and H. A. Ratcliff on "Recent Developments in Street Lighting in Manchester," read before the Institution of Electrical Engineers in 1910 and 1913 respectively.

The Extent of our Scope.

While it is true that advance can only be made by specialisation, and that the leading engineers of the day are specialists, the peculiar value of a Society such as ours is that the membership, and therefore the audiences, and hence the discussions, are representative of interests which not only widely differ, but are in some cases in spirited competition. It was predicted, when this Society was founded, that it contained elements so antagonistic, that it could not hold together. This prediction was wrong. The Society has been held together by the bond of science, and the fact that it has been so held, proves, if proof were needed, that it is essentially a scientific society. We are ready to hear what an engineer has to say about the distribution of gas or electric light to thousands of consumers, and we are equally prepared to listen to the criticism of a needlewoman on the lighting of her worktable. And since we are anxious to help architects, borough engineers, factory owners and inspectors, railway managers, searchlight operators, directors of museums and picture galleries, dyers, drapers and market salesmen, and five hundred other users of light, to use light economically, conveniently, usefully and efficiently, we seek their co-operation. We include makers, sellers, buyers, and, what is very important, the users.

In some industries manufacturers discuss designs and processes with each other, more often with the object of cheapening production than of any other advantage to the user. The user has no voice in the matter, and sometimes no choice. He is told more or less politely to "take it or leave it." Electric and gas fittings, and, to a smaller extent, oil lamps, are offered in sufficient variety to lead the purchaser to think that he uses some discernment of utility and judgment in taste when he makes a selection. But what really happens is that the best selling lines are pushed at him, and little or no attention is paid to his attempts to describe his wants. Our Society already includes members who have such wide interests, that its views should be broad, and axe-grinding motives and cheese-paring policies should find no encouragement, but improvements in usefulness, excellence of quality, efficiency in operation, comfort, and artistic merit should be promoted and advanced.

"The Eye alone is the Judge."

When our members are called upon to advise on the lighting of some place or building, or to carry it out, they examine the conditions and consider the requirements; they recommend the most advantageous method and calculate the appropriate arrangement of lamps. If the job is one of some importance, a specification is drawn by a consulting engineer, tenders are invited, the best one is selected, a contract is made, and the work is carried out by a contractor. The results are checked by a photometer, and the client is told that the job is finished. Then he comes and judges whether the lighting is "good or bad" merely by using his eyes! This is one of the difficulties of our branch of engineering, and it warns us not to rely too much on rules and formulæ, and that we must interpret the readings of our photometers with discretion. The instrument may make a definite statement, but we must consider the context.

For this reason our Society seeks the assistance of that branch of the medical profession which cares for our eyes—that branch to which our distinguished retiring President, Sir William Bennett, belongs. We also look to physical science in connection with new sources of light, and to applied mathematics for methods of exact or of ready measurement. We are dependent on that difficult branch of chemistry, the art of glass-making, and we must be able clearly to explain to manufacturers what we want, and to see that we get it. Few, if any, scientific societies spread their activities over so wide a range and are in touch with so many different arts and industries. When a subject is considered in a truly scientific spirit, trade interests disappear, and professional competition is forgotten; for the muses, when they dance, hold one another by the hand.

Solus oculus est judex, wrote Lambert: The eye only is the judge. Even if an instrument should one day be invented, as Lambert hoped, which would indicate a quantity of light on a scale like a thermometer, our client's opinion of the lighting will not be materially influenced. Illuminating engineers must therefore give some attention to the subjective and to physiological interpretations of sense-impressions. These are generally of a complex character, and one of the first steps is to disentangle the factors, so that they may be dealt with one by one. Our Society has studied the question of glare. A good deal has been written and said about it. We all know that glare is the effect of a dazzling light; but that does not define glare, it only evades the definition by shifting it. It is much more easy to suggest means for avoiding glare than to define clearly what we mean by it. This is because it is a complex phenomenon arising from the relation of multiple sensations, while dazzle generally means too much light, which is a comparatively simple affair.

The Philosophical Side.

Those of us who give attention to the scientific side of our work should turn sometimes to the psychology of it: the empiric, experimental and observational psychology of course, not the metaphysical. "The psychological equation," observed *The Electrical Times* recently, "is entering more and more into these lighting problems." The rats seen by delirium tremens patients are subjective. An after image of a bright light is subjective according to some psychologists, but it is obviously due to and associated with an external stimulus. The nature of the peacock's feather or phosphene "seen" when we press the corner of our closed eye is not optical, the retina does not appear to be functionally concerned, but is due to a mechanical stimulus. Our sense-impressions are often misleading, and we allow ourselves deliberately to be deceived when we use a stereoscope. We seem to perceive extension in space and solidity of form when the object before us is flat and has no solidity.

The old Greek philosophers who did so much thinking and so little experimenting had queer ideas about light and vision. Empedokles, who died about 420 B.C., considered it necessary to record the fact that darkness is not a real thing, but privation of light; and that the moon shines with reflected light, but he thought that the sun is the primary fire of the light of the sky reflected in a crystalline spheroid. Demokritus, who died about 370 B.C., held that vision was to be explained by emanations or exceedingly thin husks or films which were continually being detached or thrown off from the surface of bodies, and that they penetrated into the sense organs through fine passages or pores. We admit this in the case of taste and of smell. These ghost-like forms or images were called *eidola* (εἴδωλα), whence we have the word idol (a very different kind of image from those considered in optical books) and were supposed to be ever passing from the object to the moist and receptive surface of the eye straight into the mind. Aristotle, who died about 325 B.C., seems to have objected to some of the earlier theories. He hardly alludes to light and vision in *De Physica*, but there is some reason to suppose that a treatise by him on optics has been lost. More than two centuries later Lucretius, the scientific poet, discussed the theory at great length in his fourth book. He used the expression *simulacra quasi membranæ*, resemblances like films, peeled off from the upper surface of things, flying hither and thither on one side and the other through the air. *Simulacra* was also used for ghosts, and he goes on to explain how they terrify us in sleep. He also attempted to explain the action of curved mirrors, of the distance of the image behind a mirror, and why the theory does not work in the dark.

The schoolmen in the Middle Ages tried to follow Aristotle as closely as they could, but matter and form probably did not mean to them what they meant to Aristotle or to us. The *eidolon* was still used, but the expression had lost its materialistic signification. At the end of the 16th century men began to shake off dogmas of authority, to think for themselves, and to follow inductive lines of reasoning.

We may perhaps flatter ourselves that in our branch of applied optics we are not trammelled by fundamental theory, and that if the corpuscular hypothesis of light came back again into fashion next week to replace the undulatory theory, as the electron has pushed aside the elastic ether hypothesis which satisfied us in Maxwell's days, we should carry on with no change in our methods.

Nomenclature.

As knowledge advances, new terms become necessary to express new concepts. In our branch of science, new terms do not grow by accretion as in chemistry or zoology where each newly discovered substance or animal must receive a name. They multiply by fission, by the discovery that an idea, hitherto considered simple, is complex. Except in that branch of our work which deals with illuminants, our percepts remain much the same as those of Bouguer and Lambert in the middle of the 18th century. Nor did those pioneers discover new phenomena; their work was to describe systematically, in words and in mathematical symbols, visual impressions of ordinary experience.

The nomenclature of electrical terms has received the attention of the International Electrotechnical Commission. The British Committee appointed a nomenclature sub-committee of which I had the honour of being Chairman. That British Committee is now absorbed into the Engineering Standards Committee. It still includes nomenclature in its work, but if any action is to be taken on optical terms, representative of British practice, the co-operation of the Optical Society and of the Physical Society, and of the Institution of Gas Engineers, as well as our own Society, should be sought. Electrotechnical nomenclature has been settled on a wide basis; Germany took part in the work and materially impeded it by its suggestions.

Our Society has many foreign Corresponding Members, some of them in countries with which we are at war. It is quite possible to fight with an enemy whom we honour, but where there has been dishonour relations must be suspended. As scientific men we look forward to the time when scientific intercourse can be renewed. After the war we shall no doubt be prepared to treat individuals on their merits if it can be shown that there is absence of participation in the outrage to civilisation of which we complain. Meanwhile we must wait until those who were at one time associated with us realise and repudiate the perfidy and brutality of their countrymen.

Metaphysical discussions owe most of their perplexing entanglements to vagueness of terminology. Let us who study that branch of engineering and optics which deals with illumination at least understand each other as to the meaning which we agree to attach to the technical terms which we employ. The nomenclature of our subject has three aspects. One takes in the terms in ordinary use and includes some recognised but more rarely used expressions of a mathematical character. Another presents new terms or new relative orders or arrangements of terms. The third is the international outlook. It is fortunate that the vocabulary of illuminating engineering is not a large one. Most of our terms are borrowed from everyday language, such as brightness. We may have to restrict its application sometimes, by speaking of intrinsic brightness, and we must make up our minds whether it should be applied to a body which reflects light as well as to a self-luminous body. We must all agree what we mean by it and what we do not mean. Then again, we sometimes find it necessary to coin new terms, borrowing if possible a Latin word, such as Lumen, Albedo, or Lux. The man who first suggests such a term usually becomes the authority for its application. Lastly there is the correct translation of terms used in other countries, and the difficult question of logical sequence. An example occurs in the well-established use of candle and candlepower in English, and of the absence of any such expression as candlepower in French. The difficulty here is unusual in scientific nomenclature. The result is that while we have hitherto referred all photometric measurements to a more or less ideal candle, as the French used to refer to a *bougie* or to a *carcel*, we have accordingly derived our system of measurements from it. There is a proposal to use the lumen as the fundamental unit and to make the candle and candlepower secondary or derived quantities. This is the outcome of the clear philosophical logic of French science, and it has appealed to the academic type of mind which has recently made its appearance in America. Our Society has given some attention to the controversy which has arisen, and while we all admit that the lumen offers certain advantages in simplifying calculations by suppressing 4π, if the question of the fundamental unit or photometric quantity is to be pressed, that controversy will have to be continued.

Controversies.

We have had a great controversy also about street-lighting, and in their efforts to carry their views, members have done much useful work. The interesting paper on " The Mechanism of Colour Vision," which appeared in the last number of the Proceedings of the Physical Society of London might never have been written if the author had not been stimulated to controvert statements made in another " Theory of Colour Vision." The history of any subject will show that controversies are not ended by the arrival at a settlement which accords with the views of a majority who succeed in convincing a minority. A majority may thus override opposition and carry their views into action, but few persons who hold strong opinions give them up in consequence of argument or change them after hearing a debate.

In the Middle Ages logic was taught, not to help people to think and to argue, but to inquire how right thinking was done. At all times people thought straight by common sense who have never heard of premises and syllogisms. Logic asserted that if you start from true premises and employ exact methods of reasoning, you must arrive at a true conclusion. But the only way of ascertaining that the premises are true is to reduce them to self-evident axioms, and we are just as liable to err in this analytical direction as in the opposite synthetical process of building up an argument.

The difficulty in controversial matters is to avoid prejudices. These are not so much pre-judgments as the attachment of too great or of too small importance to the ideas from which we start; a failure to distinguish between the essential and the accessory. Prejudices resemble internal stresses which cause heterogeneity in a body: troublesome when we are cautiously cutting our way through, and leading to unexpected cross-cleavages if we impetuously use force. Controversies may be said to arise from the polarisation of opinions. What was apparently uniform and continuous in character becomes divided into parts which differ strongly or antagonistically owing to the operation of some external agency. The depolariser required is called tact, a term for which there is no synonym. Changing the analogy again, interests which differ, move in parallel and harmonious flow without conflict as long as they go slowly. But when some accelerating force hurries things on, the condition of turbulent flow is reached, eddies are set up, and energy is uselessly expended. When the disturbing influence is removed, when the channel widens and the stream flows more slowly, controversies disappear and years afterwards it is difficult or impossible to recall the reasons for the raging.

Controversies have a habit of settling themselves. Minorities who bide their time instead of beating their heads against a wall, find that the views which were at one time so strongly opposed become adopted and blended with those of their former antagonists.

Cognate Institutions.

By reason of the wide range of our interests, we are in touch with several different scientific bodies from which we should derive help by offering them as much assistance as we can. Their function is to turn the mills of organisation, ours to supply a share of grist.

The National Illumination Committee of Great Britain.

This is a body affiliated to the International Commission on Illumination. It was constituted in 1914 by the co-operation of our Society with the Institution of Electrical Engineers, the Institution of Gas Engineers, and of the National Physical Laboratory, to carry on and to develop the work which had been begun by the original International Photometric Commission. The first Committee consisted of Messrs. Edward Allen, Frank Bailey, John Bond, W. J. A. Butterfield, Harold G. Colman, W. Duddell, Kenelm Edgecumbe, Leon Gaster, R. T. Glazebrook, F. W. Goodenough, Haydn T. Harrison, James Kerr, J. T. Morris, C. C. Paterson, S. P. Thompson, A. P. Trotter, and Robert Watson. The first three bodies have five members each and the last one, two members. Mr. Edward Allen was Chairman, Messrs. Duddell and Trotter Vice-Chairmen, Mr. Butterfield Secretary and Treasurer, Mr. Colman and Mr. Duddell Representatives of Great Britain on the Executive Committee of the International Commission, with Mr. Paterson a Secretary of that Commission. Mr. Edward Allen died in 1915, and Mr. Duddell succeeded him as Chairman, Mr. Bond replacing Mr. Duddell as Vice-Chairman. Mr. Jacques Abady succeeded Mr. Allen as a member of Committee. Mr. Butterfield desired to cease to act as Secretary and Treasurer, but no appointment has been made owing to the suspended action of the Committee during the war.

The Committee have given preliminary consideration to a uniform international method of rating and marking all sources of light, and to the nomenclature of photometric terms. When their work is resumed the Committee will doubtless co-operate with any other bodies, such as the Engineering Standards Committee, who are dealing with these subjects.

The Committee invited a number of laboratories and private individuals to investigate the relation between the height of the flame of a Hefner amyl-acetate lamp and its luminous intensity, with the object of settling the height at which it would give a light equal to one international standard candle, that is to say, to 1·111 times the light of the usual 40 mm. flame. Five reports were received, and these, together with an American paper and Liebenthal's original work, gave a mean result of 44·2 mm. for the height of the flame. Excluding two for special reasons, the remaining five are within a range of half a millimetre or about two per cent. of light. While this is a satisfactory performance for a lamp introduced so long ago as 1884, it is not sufficient for scientific work of precision. The investigation should not be a difficult one. Corrections due to external conditions, to the quality of the amyl-acetate, and to personal equation in estimating the height of the flame, do not affect the result. The weak point probably is the difficulty of estimating the tip of the flame. The Committee have not yet issued a report on the investigation, and I have ventured to make this preliminary statement of the result without their authorisation.

Dr. E. Ott, of Zurich, a member of the original International Photometric Commission, sent to the British Committee a paper on the dependence of the light of the amyl-acetate lamp on atmospheric conditions, more especially on atmospheric pressure. The paper was translated by Mr. Butterfield, and was published in the technical Press. The results for atmospheric pressure agree with those of Butterfield, Haldane and Trotter, which were communicated to the meeting of the International Photometric Commission at Zurich in 1911. The difference for the effect of aqueous vapour is inconsiderable, and the effect of carbon dioxide was found by Dr. Ott to be smaller than by the British investigators. Dr. Ott is of opinion that a long series of investigations would still be required for a final settlement of these corrections, and hopes that a steadier and more easily managed unit of light will be found

The Engineering Standards Committee.

Reference has been made in connection with rating and marking of sources of light and with nomenclature, to the work of this Committee. Important work has been done for it on tests of electric glow-lamps, but the progress of recent years has rendered much of these obsolete. The published results did not disclose the names of the makers, but they suggested lines on which specifications might be drawn. This is intimately connected with the general question of rating. The proper rating of the output of a machine is of high importance, for many of the conditions of use have to be considered and defined. If the Engineering Standards Committee had done nothing but settle the question of rating of machinery they would have done valuable work. The rating of a lamp is of a much more simple character, and the question whether its output of light or its consumption of gas, oil or energy should be stated, is easily met by giving them both.

A Legal Standard of Light.

The unit of luminous intensity has been agreed upon by France, Great Britain and by the United States, and will probably be adopted by all civilised nations, and we call it the International Standard Candle. This is a rather unfortunate expression, for it makes a confusion between a unit and a standard. The unit may be embodied in a lamp burning pentane, amyl-acetate, or some other substance, or in an electric lamp, or as the average of a group of lamps, and may be one-tenth, or any other accurately known fraction of the light emitted by the lamp. The unit was at one time embodied in a certain kind of candle, subject to certain corrections. It was natural to call this the standard candle, and it seemed redundant to state that it emitted the unit of luminous intensity. Great confusion was made at one time in electrical science between units and standards, and we should be on our guard. We are all agreed upon the unit, which is derived from the old Parliamentary candle, and still bears the name, but the desideratum now is some actual apparatus which can be constructed to a definite specification, and, subject to working corrections, can be relied upon to emit unit luminous intensity.

A calorific test having been substituted for a luminous test of the quality of gas, it seems likely that the 10-candle Pentane Standard which has been for some years a standard of a very limited nature, will be dispossessed of the small legal dignity with which it was invested. It was only the standard for London and for the few other places which adopted it: for the brief authority of the Gas Referees is restricted to the Metropolis. Administrative changes will be made before a legal unit or standard of light is constituted, and perhaps we shall follow the action of other countries where science is not so despised by officialdom.

The Department of Scientific and Industrial Research.

It was briefly stated in our last Annual Report that a deputation of our members approached this Department in March, and submitted descriptions of the work of our Society and the directions in which it appeared that the operations of the Department might be extended to illuminating engineering. The result was that a Joint Committee of the Standing Committee on Engineering and on Glass and Optical Instruments, on Illuminating Engineering was constituted as follows. Engineering Standing Committee: Sir Maurice Fitzmaurice, Mr. J. S. Highfield. Glass Standing Committee: Sir Herbert Jackson, Prof. C. V. Boys. Co-opted members: Dr. C. Carpenter, Mr. F. W. Goodenough, Mr. L. Gaster, Capt. J. Herbert Parsons, Sir John Snell, and myself as Chairman.

This Department is one of an altogether new type. The officials are not chosen for proficiency in their knowledge of Chaucer, and they have not an instinctive dislike for science; on the contrary, they are most sympathetic. To have a good grasp or even practical experience of a subject is no longer a bar to membership of a committee. The Committee will not look upon the production of dreary official reports as the ultimate object of their labours. "Is all this important knowledge," wrote Florence Nightingale, "this strong, practical, good sense? . . . Is it to be buried in that most undisturbed grave of wise thought and useful information, a blue book, that most repulsive, unapproached, unapproachable place of sepulture?" The object of the Department is to cultivate, not to wither what it touches. It helps by inviting practical men to meet each other, and by finding funds for collection of information and for experiments. A certain amount of red tape cannot be avoided in any large organisation. There is no harm in red tape in its proper place. The objects of the Department and its proposed methods are so well known, or so easily ascertained by anybody who will expend threepence on (Cd. 8718) the last Report, that it is only necessary to consider how the science and industry of illuminating engineering can take advantage of the opportunities offered.

A list of 21 subjects for research was submitted for the consideration of the Committee, some industrial, some technological, and a few purely scientific. In the first place it did not appear that any scientific research having a direct bearing on the war can be conducted under this Department better than under the naval and military Departments which are already engaged on such work. It is not difficult to suggest scientific research in directions which may lead to useful commercial developments, but which require a greater expenditure of money than seems to be commensurate with the chance of success. It is worth while to make note of these, and to wait for the proper time to bring them forward. There are other researches on pure science from which no financial return seems likely. These might be carried out after the war, and I wish them every success, although I am rather doubtful whether endowed research in pure science can ever compare with inspired research.

On the industrial side there is more to be done. The Committee have inquired, in the first place, about goods which were imported from Germany or Austria before the war, and which were not made at all in this country. They have inquired about the manufacture of such goods, and the prices and qualities of the new home products. The valuable work of Sir Herbert Jackson on the manufacture of kinds of glass which have not hitherto been made in this country is placed at the disposal of the Committee, and when their recommendations are made as to the directions in which new branches of manufacture should be started, the Committee will be in a position to provide makers with samples, formulæ, and directions for making the goods. Some business organisation will be needed. since few glassmakers do a retail trade, and supply houses will have to be informed where these goods can be obtained.

Another branch of work in which the Committee may be able to render service is the specification of qualities and performances. Twenty or thirty years ago it was supposed that a sheet of ground glass or ordinary opal glass cut off from 40 to 60 per cent. of light, because this appeared to be the result when such a sheet was interposed between a lamp and a photometer Most of us know that in such a case the direct light falling on the photometer is no longer the only light to be measured, but also the light scattered in other directions by the translucent sheet. The public is entirely in the hands of the dealers in these matters. The ordinary buyer is quite unable to make the necessary measurements. The dealer probably knows nothing about it, and few manufacturers take the trouble to find out the figures, because they are never asked for them. The man who uses an opal shade knows that he gains something by doing so, namely a soft and agreeable appearance, compared with that of a naked, dazzling lamp. He is vaguely aware that he loses something in light, but he cannot tell or even guess approximately the gain or the loss. If he is entitled for some reason to a discount of 7½ per cent., and is offered only 5 per cent., the difference is quite clear to him, and he will take steps to get it. But whether he is losing 40 per cent. or only 10 per cent. by the absorption of his glassware is altogether unknown to him. At present it is nobody's business to look into these questions, and it appears to be one in which the Committee might act with advantage to the general public as well as to the lighting industry.

Street Darkening.

It is not possible at the present time to discuss freely the desirability of darkening the streets of towns during war time as a protection against air raids, or the degree or mode of darkening if this is considered advisable. While a frank discussion on this subject would probably remove many misunderstandings, it must remain for the present one of those in which we should submit to authority in the disciplined way to which the war has accustomed us. One of the difficulties has been the overlapping of the functions of different authorities, and the adjustment of their opinions. The subject of street darkening for war purposes was, of course, new to everybody, and it is not surprising that mistakes were made at first.

That considerable section of our Society which is interested in street lighting viewed with dismay in the earlier part of last winter, not only the suppression of all that work which had been so carefully studied in connection with the Standard Clauses for Street Lighting Specification, but also the alarming increase of accidents, especially in the streets of London.

The original anti-air defences of London were hurriedly thrust upon the Admiralty, and there was no time to go into new and difficult questions, and, of course, there was no experience to give warning of the accidents which did in fact result from over-darkening. The defence was afterwards transferred to the General Headquarters of the Home Forces at the Horse Guards, and the need for some modification soon became apparent. In November, 1916, I was sent for, and was asked to consider certain points which were put before me, and, with an officer of the London District, I inspected various parts of London in which the lamps had been obscured in various ways. In one street I measured an illumination considerably less than one-ten-thousandth of a foot-candle. I was asked to consider how much light could be allowed without revealing the topography of the district. In order to study this question more carefully, I was invited to make an aerial reconnaissance from a balloon at night.

It would, perhaps, be inexpedient at the present time to describe in detail what I saw. A stiff east wind was blowing and threatened to carry the two balloons which ascended to the west. They were therefore so ballasted that we shot up at once to 8,500 feet, where we found ourselves in the calm which sometimes lies between an east wind and a higher reverse current. There was plenty of time to study the lighting over a district of some five or six miles in diameter. The night was clear, cloudless and moonless. The most striking feature was the unmistakeable contrast between the black river and parks and the dim shimmer of the gloomy houses. Innumerable windows with drawn blinds gave the appearance of a granular film of brightness nearly equal to that which would have been produced by an illumination of 0·1 foot-candle. At that date, the streets were easily traceable by the patches of light below the screened lamps. The sight was very beautiful, and it is sufficient to say that the authorities are of opinion that it is impossible to hide such a city as London by reducing the street-lighting. On the other hand, this does not apply to small towns, for, during a run of forty miles into the country, after the waning moon had risen, at the trailing height of 350 feet, it was impossible to distinguish between houses and haystacks. A small town and several villages were crossed without being seen. I can confidently assert that it is possible to obliterate a small town by extinguishing all street lamps and by careful shuttering and screening of the windows. But this screening must be intelligently carried out.

In the warfare of the future we must expect surprise attacks by large air squadrons. It will be necessary for engineers to consider the best means for control of street lighting, and, indeed, of all outdoor lighting, from the source, and provision for immediate extinction, when called upon by the military authorities to take this step. An independent street lighting system affords an excellent method of giving warning of an air-raid at night. There are very few instances of separate mains for street lighting, but a relay system for the control of electric lamps has been successfully tried and seems to be applicable for this purpose. It must be remembered that our coast towns, and indeed those near the coast, are visible from a considerable distance at night, in peace time. Enemy aircraft, deprived of the guiding lights of towns, have often hopelessly lost their way, and have scattered their bombs on open fields. Complete darkening of the whole country is undesirable for many reasons, even if it were possible, but a carefully considered reduction of lighting is in many cases well worth much inconvenience and some risk of accidents.

Without criticising the earlier or the present way in which the civil authorities have obscured the street lamps in London, it must be admitted that the coat of distemper on the glass panes of the lanterns gives a delightfully soft and agreeable effect. It contributes nothing to the uniformity of illumination which would disguise the topography of the district, and of course it is very uneconomical and inefficient. It is doubtful whether we shall ever return to the blatant glaring over-lighting of the years preceding the war; and when the lights are "turned up" again, the public will demand quality when they are offered quantity.

Future Developments.

The industrial and the consequential social changes and redistribution of wealth which may take place after the war do not appear to affect our Society in any particular way. We can point to a long-established and successful case of profit-sharing by one of the largest gas companies, and a recent and encouraging example in one of the smaller electric supply undertakings. Whatever changes of this kind may await us in the future, we are certain that scientific research has great things in store for us.

Distillation is said to have been discovered by the saturation of a fleece placed over a tub of wine. For many centuries the distiller sought one product only at a time. There are about 25 chief residual products of the distillation of coal, and to-day it is doubtful whether the word residual should be used at all, and which is the most important product to be aimed at. With my limited knowledge of the gas industry I can make no anticipations of its future. Coal gas and electric lighting will probably become by-products of chemical manufacture and of the supply of power respectively. In any case, however, we may confidently look for great advances in artificial lighting.

Fireworks and Fireflies.

Our first President, the late Professor Silvanus Thompson, in his Inaugural Presidential Address on the founding of our Society, referred to the youthfulness of that branch of engineering which we practise. It recalled, he said, illuminations on the proclamation of peace after the Crimean War. "Bengal lights and rockets. How the vision of them stands out in memory. But our Society has as little to do with fireworks as with fireflies. As little—and as much—for, after all, both of them are assuredly of some interest to the illuminating engineer."

He knew that the secret of the firefly is still hidden from us, but that if we knew it, if we knew how to produce the rapid vibrations which give the stimulus called light, without producing all the slow ones as well, as when we sound a high note with a finger instead of pressing all the keyboard at once, the mechanical equivalent of light would be as important as the mechanical equivalent of heat, and we should be able to produce light without heat. The quantity of energy which appears as useful light is about 2 per cent. of the energy radiated from an electric glowlamp ; in the firefly it is about 96 or 97 per cent. In other words, if we could produce a highly efficient lamp, the light-generating output of a dynamo would be fifty times greater than now, and 45 lbs. of coal would do what a ton does to-day. The cost of lighting will not be reduced in anything like the same proportion. The cost of fuel is about one-tenth of the selling price of the light. The ordinary London householder pays 3d. to 6d. for his domestic lighting, which entailed a consumption of about 0·44d. of coal at pre-war prices.

Fireworks.

While so many engineers and scientific men have been eager to do something for the war, and so few have succeeded in finding any appreciation of their services, our Society must be content to have been allowed to carry out more than one investigation for which it was well fitted. Silvanus Thompson said that fireworks, as well as fireflies, were of some interest to the illuminating engineer. The star-shell, flares, and parachute lights which play so important a part in the war, are but fireworks. The chemist has used his skill to choose the most suitable compositions, and ingenuity has been expended in putting them up and in priming them; but in estimating the results, no further progress had been made beyond the stage of Lambert—the eye alone was the judge. Fortunately the right men in the right department were approached. It was recognised that photometric tests would be useful. Our Society offered to find men who would suggest methods, and give their time if necessary to carry out the work. A committee was accordingly formed ; it conferred with the experts, who cordially placed their data and requirements before the members ; a special photometer was at once discussed, designed, and made. At the present time nothing more can be said than that the instrument has fulfilled all expectations ; it needs no manipulation whatever during observations, measurements may be taken over large ranges, and the behaviour of unsteady or flickering lights, can be recorded. The observations on a large number of samples, both of service patterns and of experimental kinds, were made by the committee during night meetings, and were reduced to candle-power-seconds per gram of composition, and it is hoped that the results have been useful.

Gun Sights.

Some five and twenty years ago it seemed likely that luminous paint would have many useful applications, but the results were disappointing. The preparation of one of the best kinds was kept secret and it was never properly placed on the market. Night operations of war have directed attention to this subject, and the old method of exciting zinc sulphide or other materials by light has given place to continuous stimulation by alpha rays of radium compounds. Dials of watches and compasses are well known, and luminous gun sights are no secret, but there are other applications which cannot be described at present. On these, a committee of our members has been working. Tiny tubes are used which are smaller and give less light than a glow worm, but in their preparation careful photometric measurements of considerable difficulty have been made, and valuable information has resulted from the research.

Physiology.

More work is wanted, or at all events more accessible literature is needed on the physiology of vision. The dioptrics of the eye are well understood ; its normal, abnormal and pathological characteristics are the basis of opthalmic science. The theory of colour vision is still, perhaps, unsettled, though no one worker will admit it. The subject to which I wish to refer is a purely quantitative one, and is the relation of light flux to visual perception. The range of the luminous stimulus to which the eye can respond is enormous. When we grope our way on so dark a night that objects are only just visible, the illumination is about one ten-thousandth of a foot-candle, or equal to that received from a candle at a distance of 100 feet. In summer sunshine we often have 5,000 foot-candles, and in clearer atmospheres than ours, 10,000 foot-candles are reached. The brightness of a furnace is even higher, and furnacemen judge the temperature by the colour.

By some marvellous organic control the eye so reacts that it is capable of estimating difference of tone and colour over a range of several thousand millions. The contraction of the pupil has very little to do with this regulation. It merely seems to take advantage of a greater stimulation to reduce spherical aberration. Over a large part of the enormous range Fechner's relation between stimulus difference and sensation difference holds good. There must be some intricate and delicate provision, perhaps, of a chemical change in the receptive portion of the eye, the retina, depending on saturation or exhaustion of material; or some inhibition of the transmissive portion, the optic nerve; or some compensatory reaction or opposing activity or fatigue in what Huxley called the sensificatory portion, the brain. The automatic adjustment of control which permits so sensitive an organ to accommodate itself to so great changes in the external stimulus, has its counterpart in other organs and functional mechanisms of the body, such as those which are concerned in breathing. If physiologists could tell us something about this quantitative control, it would help us in several ways.

Conclusion.

Some of our members have had to divert their attention from their ordinary work and to turn their energy in new directions. Many with reduced staffs have worked as they have never worked before. Some new enterprises have been laid aside for want of material, others have been stopped for lack of capital. Our working committees for the examination of library lighting, school lighting, and factory lighting have suspended their work for the time being. But our Society has not despaired, because we are convinced that a great field of usefulness lies open to us in the future, in the science and industry of illuminating engineering.

DEPARTMENTAL (HOME OFFICE) COMMITTEE ON LIGHTING IN FACTORIES AND WORKSHOPS.

We observe that Sir George Cave, in reply to a recent inquiry by Mr. Pemberton Billing in the House of Commons, said that the Departmental (Home Office) Committee on Lighting in Factories and Workshops presented a first Report in May, 1915. Owing to the war, the further inquiries contemplated by the Committee had to be suspended, and there had been no meetings of the Committee, no change in personnel, and no expense incurred in connection with it during the last two years. Good lighting in factories and workshops was of great importance to the health of workers and for the prevention of accidents, and had also a considerable effect on output. It was proposed that the inquiry should be resumed as soon as circumstances permitted.

This authoritative endorsement of the importance of good industrial lighting is very gratifying, and it may be hoped that it will not be long before circumstances permit the resumption of its inquiries by the Committee.

N.B.—The various items in the present number are included in the accompanying General Index for 1917.—Ed.

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